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BRANDENBURG CENTRAL STATION

Turbine Prime Movers for Generating Units and Pumps. Boiler, Economizer and Superheater Combined in One Unit

BY DR. ALFRED GRADENWITZ

THE FORTHCOMING OPENING OF the Berlin-Stettin waterway, navigable for large ships, lends additional interest to the power distribution system and the generating station at Hegermuhle, about 2 miles from Eberswalde, adjoining the Finow Canal. This extensive power transmission designed by Dr. G. Klingenberg, Director of the Allgemeine Elektricitats-Gesellschaft, supplies the following principal consumers: Brick works, with about 2000 working hours per year and a simultaneous maximum demand factor of about 100 per cent; factories with from 3000 to 7000 working hours and a maximum demand factor of from 40 to 70 per cent; parishes and farms with about 150 to 1000 working hours per year and a maximum demand factor of about 35 per cent.

For the first installation a maximum consumption of about 2300 kw. was assumed, and for the second and third installations about 5500 and 8800 kw. were estimated, respectively. On account of the large amount of power consumption the most suitable sizes of ma-

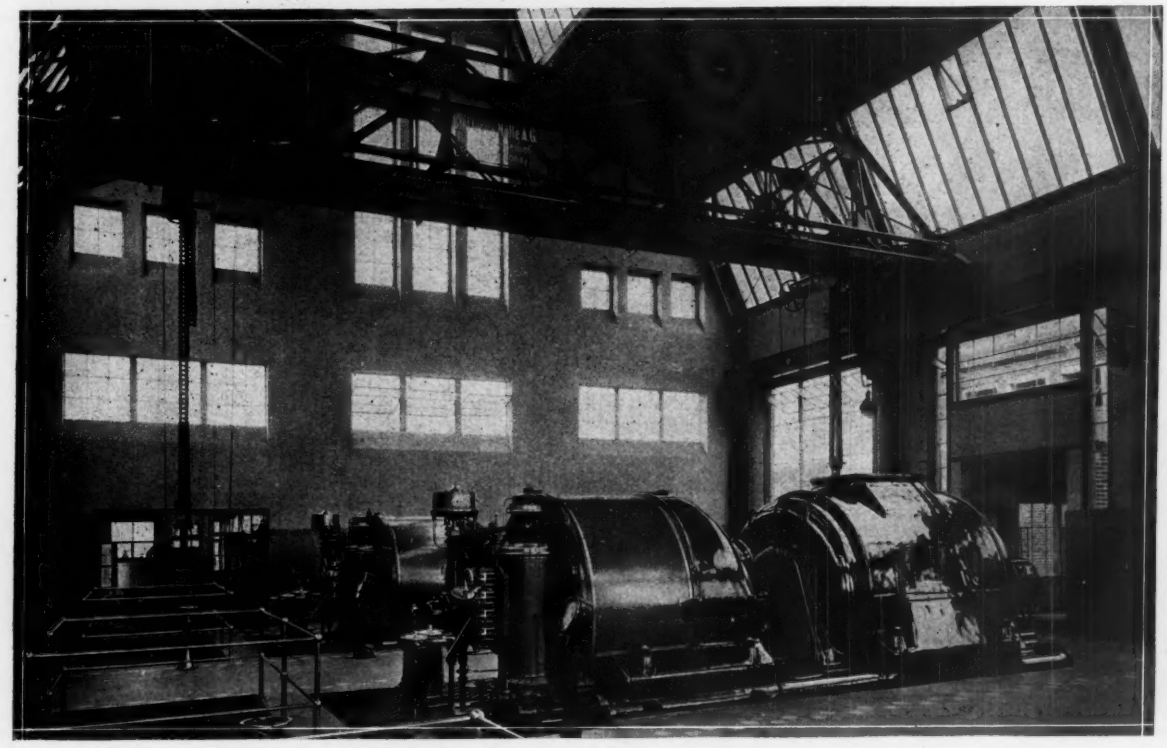


FIG. 5. PART OF THE TURBINE INSTALLATION

chines were considered to be units of 3600 kw. each at 80 per cent power factor. The engine house was accordingly designed for accommodating 3 steam turbines and the boiler house for 6 boilers supplying 26,448 to 33,060 lb. of steam per hour; 2 steam turbines and 3 boilers will be further provided as reserve units.

The generating station stands close to the waterway referred to above. The central lines of the boiler and turbine rooms are at right angles to one another.

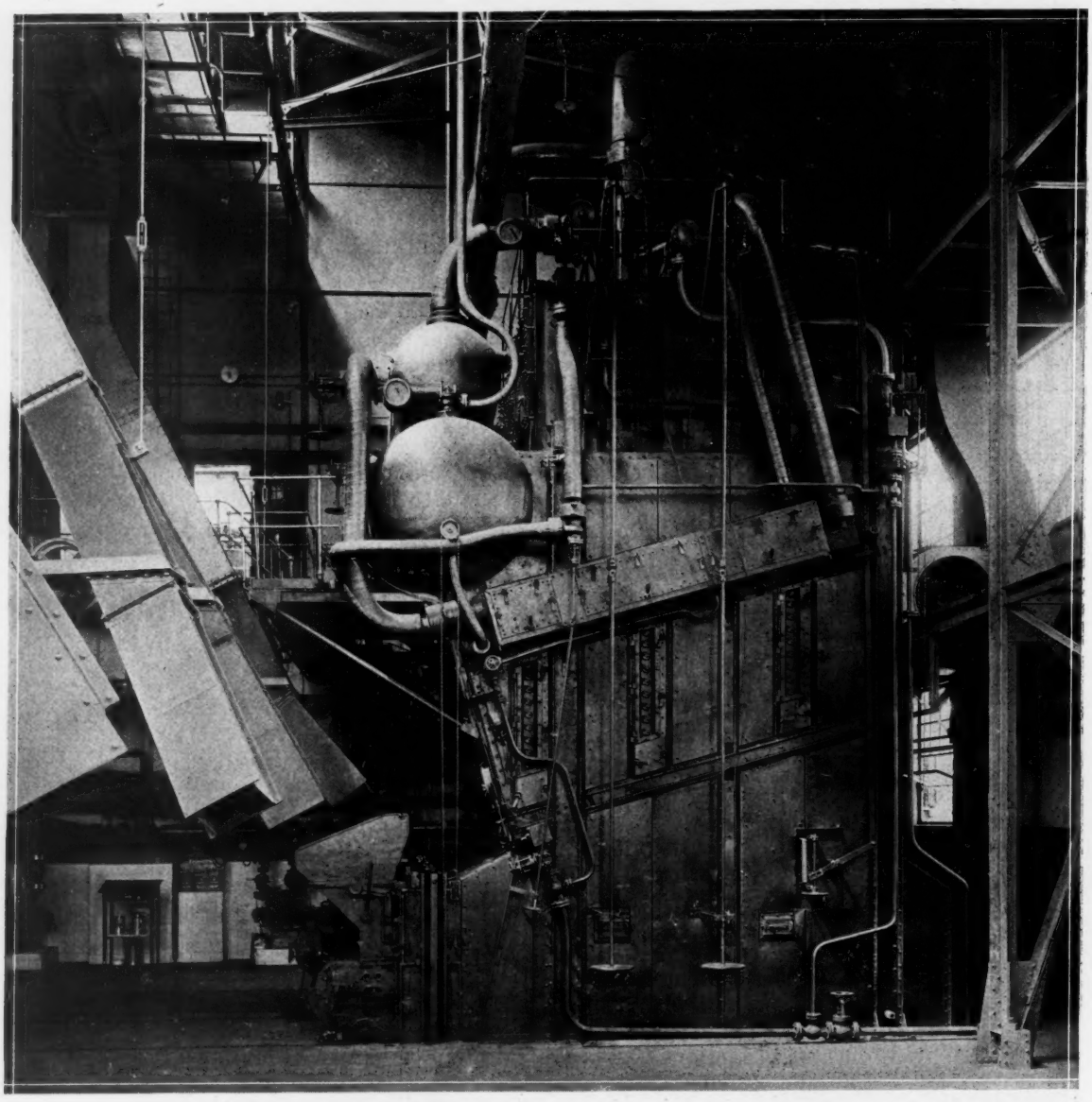


FIG. 2. BOILER WITH SUPERHEATER IN UPPER PASS AND ECONOMIZER ABOVE

A special building connected with the turbine room by a covered bridge houses the switchboard and electrical apparatus. Figure 1 shows a general view of the station from the canal side.

Coal Supply

A PRIVATE harbor was constructed on the Finow Canal which can accommodate 2 200-ton barges. Adjoining the harbor is a coal storage yard which can accommodate a 4 months' coal supply; this is necessary, since during the winter months the regular supply by water cannot be relied upon.

Coal is unloaded from the barges by a discharging crane and conveyed to the coal yard. To allow for future extension, the crane runway on the land side was so constructed that a second crane can be connected to it, which is to occupy the space in front of a second boiler house. The control of the lifting and traveling movements is from a driver's cab mounted on the crab. Below the coal yard, 2 passages of reinforced concrete have been constructed in which the runways for the endless chain bucket coal conveyor are placed. Both passages have a number of openings at the top through which the stored coal falls into the conveyor buckets. As the coal is delivered in the proper size for use with chain grates, coal brushes were not required.

It was possible to restrict the dimensions of the conveyor plant, in the boiler house, to such an extent that it could be placed conveniently between the roof trusses. As the coal used gives off very little dust, it was not necessary to enclose the conveyor; it is therefore quite open and is accessible from gangways on either side. The stoker hoppers are charged by automatic discharge chutes built into each bunker in pairs and operated by a handle from the fireman's position in front of the boilers.

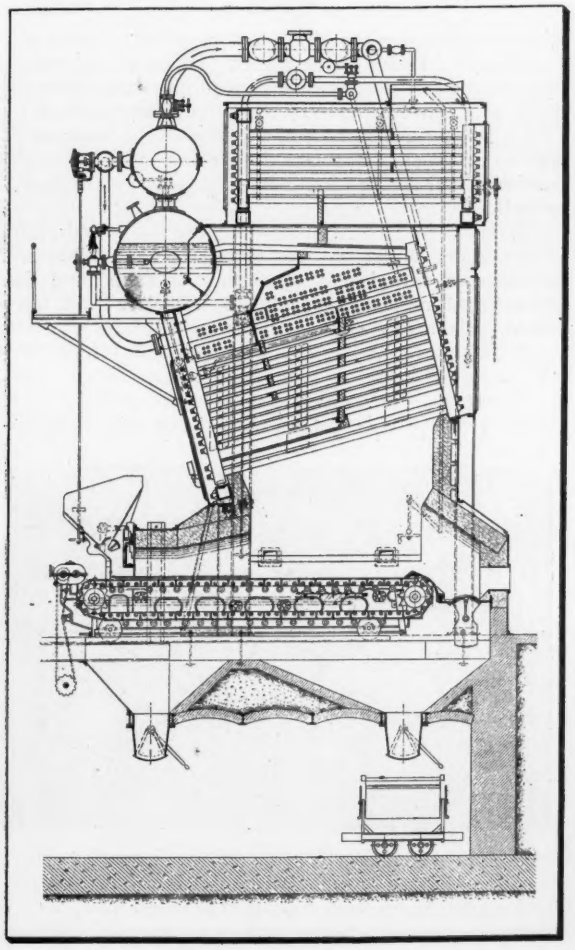


FIG. 3. SECTION THROUGH BOILER UNIT

When a bunker is full, it is automatically closed; when all of the bunkers are full, the full buckets are made to discharge over a coal holder at the back of the boiler house by a discharging device, which again tilts all the buckets to their original position. The coal in the coal holder presses down a flap which cuts out the starter of the conveyor motor. Different qualities of coal can be mixed by alternately filling the buckets at different points in the coal yard. The bunkers hold sufficient coal for but a 2-hr. supply for the boilers. In view of the reliability of the coal conveying plant, it was considered unnecessary to accumulate coal in the boiler house. The chief advantages of this arrangement lie in the extremely light weight of the iron work and in the absence of any special supporting pillars.

Boiler House

THE boiler house is designed for 6 units, each consisting of a boiler, economizer, forced draft plant and metal chimney; it occupies an area of 86.92 by 72.16 ft., 6273 sq. ft. The plant has a maximum output of approximately 209,380 lb. of steam per hour. Three of these units were installed at first, i.e., for 22,040 lb. of steam,

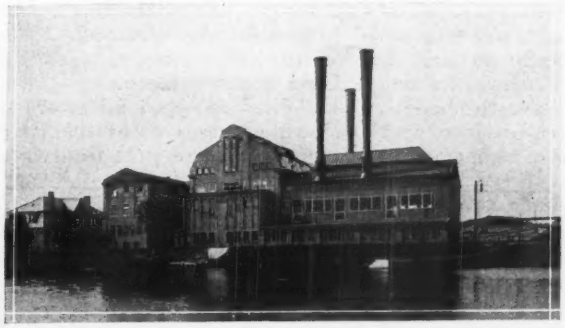


FIG. 1. THE STATION FROM THE CANAL SIDE

for which about 646 sq. ft. of ground is necessary. The weight of the iron work employed in the construction of the boiler house amounts to 213,788 lb., or about 1 lb. for 1 lb. maximum steam output.

The following are the main data of these boilers:

Boiler Output: Normal, 27,770 lb. steam per hr. Maximum, 34,713 lb. steam per hr.

Steam pressure: 210 lb. per sq. in.

Steam temperature: 662 deg. F.

Heating surface of boiler: 4411.5 sq. ft.

Heating surface of superheater: 1453 sq. ft.

Heating surface of economizer: 2260 sq. ft.

Grate area of the mechanical chain grate stoker: 159 sq. ft., the chain grate being continuously driven by a 1½-hp. 3-phase motor.

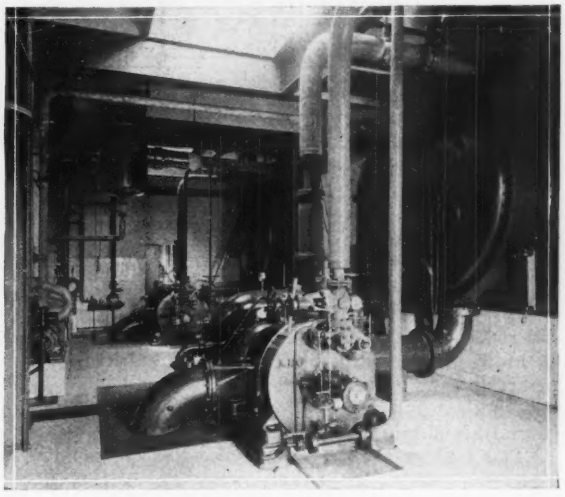


FIG. 4. SURFACE CONDENSERS AND PUMPS

Thermal value of coal: About 10,829 B.t.u.

Coal consumption per hour: Normal, 4298 lb.; maximum, 5396 lb.

Apart from the small space occupied, further advantages were derived from the low heat losses due to radiation and conduction, the upper part of the boiler

and economizer being dimensioned much smaller than in the case of the customary separate form. Notwithstanding the comparatively small height of the chimneys, natural draft can be relied on up to about ⅔ of the maximum boiler output, so that forced draft is required only at times of maximum loads.

As seen from Fig. 2, a view of the boiler room, and Fig. 3, a section through one of the units, the economizers are mounted above the boilers; the unit is compact and is covered to prevent the admission of superfluous air. To prevent water carrying over into the superheaters, a large steam collector is placed above the boilers. The boiler and economizer are so dimensioned that the heating gases enter the latter at a temperature of about 750 deg. F.; the feed water

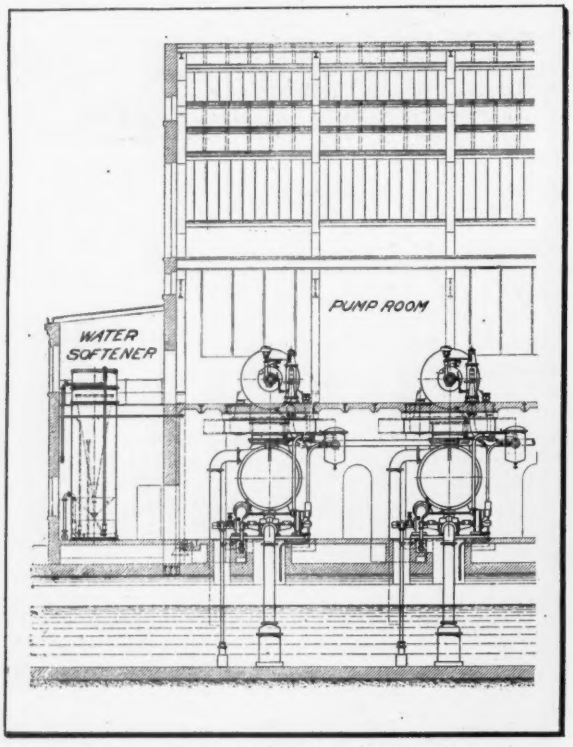


FIG. 6. SECTION THROUGH ENGINE ROOM

is preheated to 250 or 285 deg. F. Ash falls through chutes into a spacious cellar from which it is removed in carts.

Condensed water from the surface condenser, which is fairly free from air, is used for feeding purposes, and readmission of air is avoided, when the feed water is on its way to the boiler, by not subjecting it to a partial vacuum, and by storing in reservoirs having the smallest possible exposed surface. The use of any special air-eliminating apparatus is thus unnecessary.

The boilers are fed automatically by means of a Hanneman water-level regulator. The speed of each turbo-driven feed pump is controlled by a pressure regulator which regulates the steam admission so that the water pressure remains practically constant; any fluctuation in the quantity of water handled is automatically adjusted. Both pumps are of the multi-stage centrifugal type, and each has a capacity sufficient for the entire boiler supply. Only small quantities of makeup water are required for feeding the boilers. As it is drawn from the Finow Canal, and is hard, it is softened before using, the water softener being installed in a room adjoining the pump room. After passing through a water meter, the softener makeup water flows into a hot-water reservoir placed below the pump room.

Steam-piping connections to the pump turbine branch directly from the main steam line at the main steam separators. The exhaust steam from the turbines is conducted to a tank where it passes through spiral coils, preheating the feed water, which flows under pressure to the centrifugal pumps.

Piping

SHARP bends in the piping are avoided as far as possible, and roller bearings are provided to allow for free expansion. The main steam piping consists essentially of a main pipe line, which is connected on the engine-room side of the boiler house to the main steam separators, which connect with a header from which turbine-supply pipes branch. A steam separator is installed at each turbine.

Between boilers Nos. 3 and 4, the 2 lines of piping in the boiler house are connected, without, however, forming an actual ring system. As each pipe does not suffice for the conveyance of the entire quantity of steam, this arrangement serves only to increase the reliability of the system and was carried out without any appreciable extra expenditure.

A steam collector above each boiler and the steam separator in the boiler house are rigidly supported

FIG. 7. THE SWITCH CONTROL GALLERY

by brackets and side supports at fixed points. The higher steam pipes are attached to the roof by means of movable suspension hangers. The connecting piping between the 2 main steam separators is supported by brackets fitted with roller bearings to allow for longitudinal expansion; an expansion joint is installed in this piping. The 2 main steam pipe lines in the boiler house are also equipped with expansion joints.

All piping consists of seamless steel tubing with cast-steel flanges and of cast-steel fittings and valves with packing rings of a nickel alloy. The valves can be operated from the floor of the boiler house and the main valves are provided with indicators showing whether they are open or closed. All steam pipes are covered and the flanges are fitted with cast-iron insulating caps.

The reduction of thermal losses in pipe lines is of importance, and can be effected by reducing the exposed surface which depends partly on the distance between the boilers and the engine and partly on the velocity of the steam. In this plant the distance be-

tween the boilers and turbines has been reduced to a minimum by placing the boiler house at right angles to the engine house. The maximum steam velocity is about 262.4 ft. per sec.

Condensers

CIRCULATING water for condensing purposes comes to the plant through a channel lying parallel to the turbine room, and from this channel to each circulating pump through a cast-iron pipe having an internal diameter of 17.7 in. (450 mm.). The cooling water after passing through the condenser goes to an outlet, entering the Finow Canal close to the coal discharging harbor. All centrifugal pumps for the water supply are equipped with steam ejectors, operated by saturated steam piped directly from the boiler.

Standard counter-flow surface condensers, fitted with steam turbine-driven rotary air and cooling-water pump are used. Exhaust steam from this small turbine is discharged to the intermediate stage of the main turbines and is therein used to the limits of its expansion. The condensing water passes through a water meter provided for each turbine to a raised reservoir, so that the steam consumption of the turbine can be ascertained at any time. A view of the condenser and circulating pumps is shown in Fig. 4.

The turbine room, a partial view of which is shown in Fig. 5, and a longitudinal section in Fig. 6, at present provides for 3 turbo-generator sets, each having a continuous rating of 3600 kw., 80 per cent power factor, a steam pressure of from 185 lb. to 210 lb. with a temperature of from 360 deg. to 570 deg. F. at the stop valve. Nozzle regulation considerably reduces the steam consumption at low loads. All condensed water from the steam separators is also discharged into this reservoir. Circulation water for cooling the bearings of the turbo sets is supplied by small 3-phase motor-driven centrifugal pumps, erected in the condenser cellar, and also connected with the 2 main water channels.

Generators work at 10,000 volts, which is kept constant by means of Tirrill regulators. The electrical and mechanical units in the cellar of the turbine house are separated by intermediate walls and doors. The condensers are placed below the steam turbines between the foundation bolts; on the other side of the cellar the cable end sealing boxes and the air filters are arranged. Air required for cooling the generators is admitted through openings in the wall of the inner room to the cellar, and after passing through the air filter, is sucked into the generators, after which it passes through a passage on the generator side of the cellar to openings in the wall of the machine room which connect with the outer air. Each turbo-generator is provided with a switch pillar comprising an ammeter, wattmeter and voltmeter, also signaling apparatus for communication with the attendant in the switchboard building.

Controlling Apparatus

IN designing the switchboard, the greatest care was bestowed on obtaining absolute reliability in operation, and special attention was paid to those parts which would interrupt the whole service in the event of a breakdown. The most important of these are the busbars and the leads branching from them, which were made with ample distance between the different parts and a high mechanical and electrical factor of safety allowed. The necessary reserve is provided by a double set of busbars. In addition, group busbars are also provided for the distribution service to which the outgoing cables are connected in sets of four, in such a manner that the 2 ends of 1 ring terminate at different busbars.

The machine and section oil switches are designed for the maximum short-circuit current, each consisting of 3 single-pole switches; the feeders, on the other hand, are connected to 3-pole switches for low short-circuit currents, since for the latter in the case of short-circuits, only part of the output would be concerned. Every 2 groups of adjoining busbars can be connected by means of the usual switches, so that the group switches can be inspected even when the corresponding group busbars are under current.

Both machine and group switches are operated electrically, but the distributing switches are hand operated; all switches can be released electrically. The current can be cut off from the switch panel by means of section switches. Current for the electrical apparatus of the switches and for the emergency lighting of the whole plant is taken from storage batteries on the third floor of the switchboard building; they can be charged by energy from the converter.

All generators are protected by reverse current and maximum current relays; time limit relays are provided for the groups and the cables are protected by the differential relay system. The neutrals of each generator can be grounded through a resistance which in the event of a ground connection in one phase allows approximately 2.5 times the normal current to flow. The excess pressure protective system consists of water jet grounding devices and horn-type arresters arranged in the customary manner.

The high-tension apparatus is installed in the right-hand wing of the switchboard building; the cable and sealing boxes, section switches for the generator and transmission cables and the excess voltage apparatus are on the ground floor. The current and potential transformers are also placed partly on this floor.

On the first floor the oil switches are so arranged that their operation can be carried out in the central corridor, which is separated from the actual high-tension apparatus by massive walls. The busbar system with its section switches is installed on the second floor. The fact that all isolating partitions are made of fire-proof Duro plates, which can be easily worked, simplified the erection work. All end sealing boxes, transformers, oil switches, section switches, instrument transformers, etc., are provided with similar insulators. In fact, this is the first installation to be equipped with a universal system of installation, a matter of importance not only with a view to obtaining uniform safety throughout the plant, but also that all insulators are interchangeable.

The operating switchboard is in the central corridor of the first floor, and on its right is placed the operating mechanism for the oil switches, which are thus under the direct supervision of the switchboard attendant. These are shown in Fig. 7. The operating board is arranged in 2 rows, one of which contains the Tirrill regulators and generator instruments; the other is reserved for the distributing circuits. The signaling apparatus for the engine room is placed in the intermediate passage.

Above each set of cable switch gear, the 3-pole relays and the ammeters are mounted, the 3 maximum and 3 reverse current relays and the group ammeters being placed above the machine switches.

Power required by the auxiliary circuits is supplied by 2 2-phase transformers, which have an output of 150 kw. and a potential of 220 volts; these transformers are mounted in the cellar of the switchboard building. The distributing board is placed on the ground floor, in the left wing of the switchboard building. Each separate auxiliary circuit is protected by a maximum and no-voltage release, and its average consumption is ascertained by means of the meters, thus checking the consumption of the station itself.

In this plant one passes from the turbine room directly to the boiler working gangways, from which 2 convenient steps lead down to the floor of the boiler house. The boiler house floor and condenser room are at the same level and are connected by doors; the upper gallery for the water softener is at the same level as the engine room. The walls of the engine room, the switchboard building, operating and condenser room are lined with glazed tiles to a height of from 9 to 10 ft. The engine room flooring is of tiles. Sky-light lighting for the boiler house and turbine rooms is used extensively, made possible in the boiler house by the absence of coal bunkers, while in the engine room the stiff framework construction employed ensures an abundance of light.

OIL AS AN EMERGENCY FUEL

Types of Burners and Furnaces, Methods of Regulation

By Reginald Trautschold

GENERALITIES and a conservative consideration of the economic value of an auxiliary oil burning system for emergency use in and ordinary coal burning steam plant were dealt with in a former discussion. This logically leads to a more detailed description of the apparatus required. Such apparatus will be the same whether called into use only occasionally or relied upon continually, as in the case of a plant burning only oil, such as one in which the gain in efficiency and convenience due to the use of oil has supplanted the use of coal as fuel. A short description will be given of efficient types of oil burning apparatus, supplemented by plans of actual typical installations of such mechanisms.

Actual mechanisms required in the boiler room consist simply of 2 pieces of apparatus, the burners and regulator, with the necessary piping, connections, valves, etc. The burners control and regulate the respective supplies of oil and steam, both of which are advisably delivered at constant pressure unless an automatic fire control is installed, in which case the oil is supplied to the burners at a pressure varying with the load on the engines, which variation may be made use of to operate automatically dampers controlling the supply of air to the combustion chambers, so that a constant relation may exist between the volume of air admitted and the quantity of oil consumed. Automatic regulation, however, is not yet common and will be referred to only in general terms, particularly as good hand regulation can be effected by a careful operator with efficient burners, if the load on the engines is not subjected to wide variations.

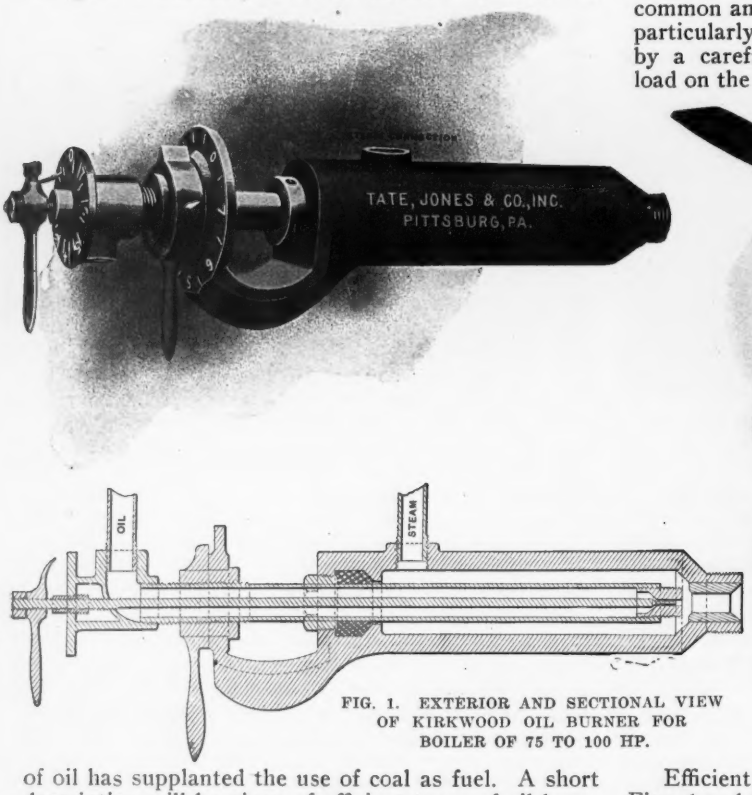


FIG. 1. EXTERIOR AND SECTIONAL VIEW OF KIRKWOOD OIL BURNER FOR BOILER OF 75 TO 100 HP.

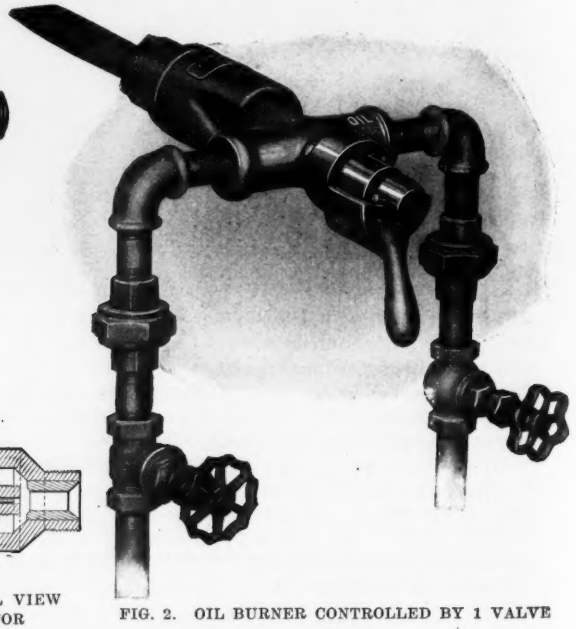


FIG. 2. OIL BURNER CONTROLLED BY 1 VALVE

Efficient types of oil burners are illustrated in Figs. 1 and 2, manufactured by Tate, Jones & Co., Inc., Pittsburgh, Pa. Figure 1 shows a type of burner of 75 to 100 boiler horsepower capacity that is recommended for efficiency and general satisfactory operation in stationary boiler work, and of which a great number have been installed throughout the country. The oil is admitted at constant pressure into an inte-

rior sleeve from which its delivery is regulated by a rod, acting as a plug in the delivery aperture, and operated by an external hand lever or handle.

Steam is admitted to the recess between the outer casing, which enters the furnace door, and the oil sleeves, and its discharge to the fire chamber is regulated in a manner similar to that controlling the oil supply, the oil sleeve acting as the plug in this case, and the delivery aperture, or nozzle, is common to both the oil and the steam supply. The steam rushing through the nozzle carries with it the oil delivery from the sleeve and the mixture is delivered in a fine vapor or spray.

Figure 2 illustrates a type of burner in which the supply of both oil and steam is controlled by one handle, the mixture being proportionally constant at all times. That is, the proportions of oil and steam are fixed in this burner, for which reason such burner is particularly adapted for use with unskilled operators, the burner efficiency being not easily impaired. The burners are installed in the furnace doors so that the flame is directed against a wall of fire brick.

Standard arrangements are illustrated in Fig. 3. The connections to the burners consist of a steam connection to the top of the boiler and an oil connection to the regulator. The steam connection contains a reducing valve which cuts down the steam pressure from that at the boiler to 3 to 5 times that at which the oil is delivered from the regulator; this latter pressure is dependent upon the viscosity of the oil and should be only sufficient to assure a constant and uniform delivery to the burner.

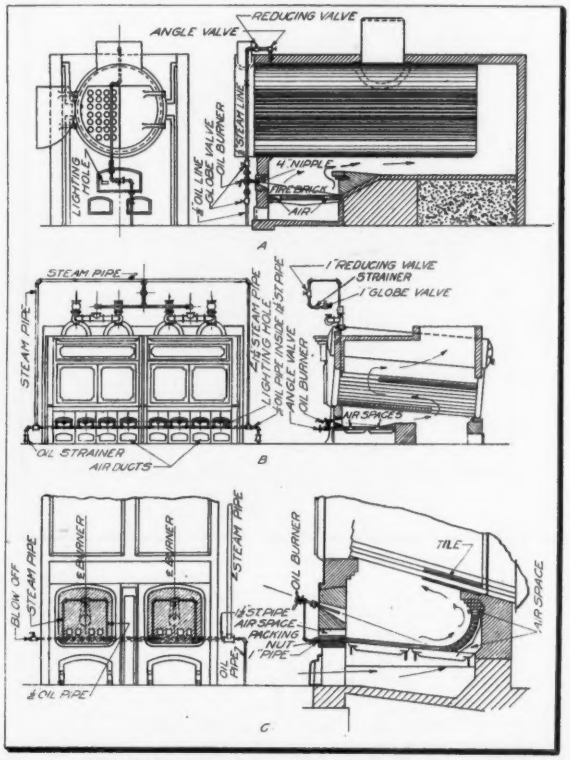


FIG. 3. STYLES OF FURNACES FOR BURNING OIL UNDER DIFFERENT TYPES OF BOILERS

Illustrations of typical installations of burners shown in Fig. 3 are: (a), application of burners to horizontal return fire-tube boilers; (b), arrangement of burners for a water-tube boiler with horizontal baffling; and (c), the location of the burner in a water-tube boiler with vertical baffling. The passage of the gases of combustion from the fire chamber to the smokestack follows the same path as would be taken by the products of combustion if coal were used for fuel, and it will be noted in each case that the grate bars are protected by fire-brick, the air for combustion being admitted only through comparatively small openings. This point is of the utmost importance as upon it the efficiency of the installation largely depends. The volume of air admitted to the combustion chamber should not exceed 15 per cent more than the theoretical requirements for complete combustion of the oil and this point will be referred to again when considering an automatic system for regulation of the fire.

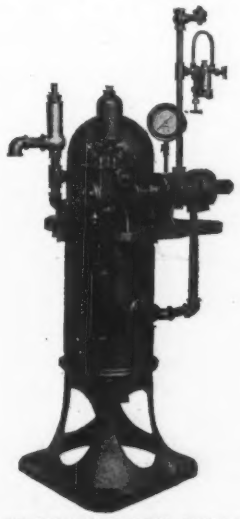


FIG. 4. REGULATOR WITH SINGLE PUMP

Two models of compact and efficient regulators, manufactured by Tate, Jones & Co., Inc., are shown in Figs 4 and 5 and well illustrate the development that has been made in this line. These regulators perform the various operations of pumping the oil from the storage tank, heating the oil to reduce its viscosity and delivering it to the burners at constant and suitable pressure. The oil is pumped directly from the storage reservoir and strained, before entering the pump cylinders, to remove any lumps or foreign material. At suitable pressure, the oil is delivered to a chamber containing the heating coils and thence is piped directly to the burners at uniform pressure, the excess of oil being returned to the storage tank.

Absence of any bulky or cumbersome apparatus from the boiler room of an oil burning system makes such a system particularly adaptable for use as a secondary system in emergencies. The plans of the typical installations shown in Fig. 6 will show that little space is occupied by apparatus for the oil burning system; the only piece of mechanism taking any considerable space is the regulator, and this may be located in any convenient and unoccupied part of an ordinary boiler room. Should the installation be one for emergency use only, the oil burners and fire-brick linings of the combustion chamber can be easily and rapidly removed, leaving the boilers and grates ready for return to coal firing and the boiler room practically free from any interfering apparatus.

The oil burning plants that have been illustrated depend upon hand regulation of the fires and the

apparatus described is particularly designed for such installations. This regulation is quite satisfactory for plants in which the load on the engines is fairly constant, for an experienced fireman can so control the consumption of oil as to assure economy and high efficiency, providing the fluctuations in load are not excessive and the installation is made with proper regard to the supply of air to the combustion chamber. As previously stated, this supply should not exceed 115 per cent of the theoretical requirements for complete combustion of the fuel and the highest boiler efficiency—about 85 per cent, or 20 to 40 per cent higher than is attainable when using coal as fuel—is obtainable only when the excess air supply is about 10 per cent.

The importance of regulating this excess air supply cannot be too strongly emphasized, for as a given supply of oil requires only a comparatively small volume of air for combustion and 3 to 4 times this amount can easily be admitted, the inadvisability of admitting too much air must be thoroughly understood. An excess air supply of 300 per cent—not an unusual condition—will reduce the efficiency of the boiler to 65 per cent or under, a common record when depending

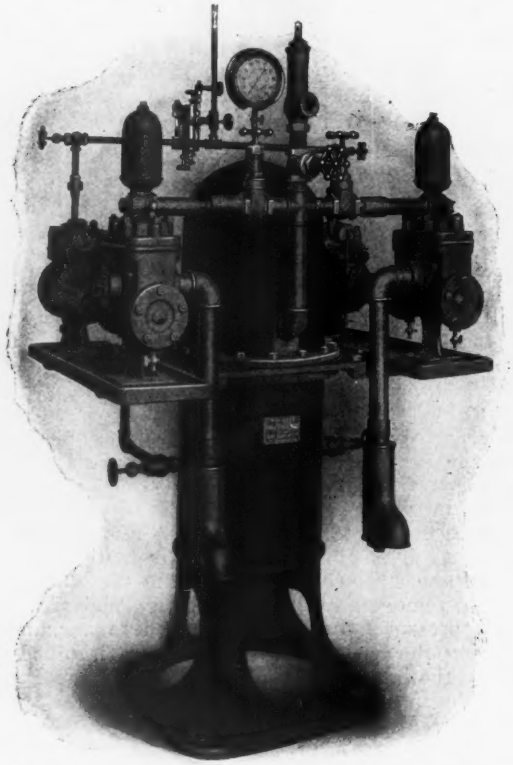


FIG. 5. REGULATING SYSTEM FOR LARGE PLANT

upon coal for fuel, and necessitate the consumption of about 30 per cent more oil to maintain the required boiler pressure.

Where the load on the engine fluctuates through a wide range and varies frequently, the most economic generation of power is always difficult, particularly in plants where oil is used as fuel. To meet a marked increase in load more steam is required and a correspondingly greater amount of heat must be furnished to the boilers to meet such demand. This means consumption of more fuel and in the case of an economic oil burning system necessitates the admission of more air to the combustion chamber for the ignition of the extra oil delivered by the burners. This admission of air, of course, can only be controlled by a system of dampers, but the economic handling of many and frequent variations in load would tax the ability of even the most experienced fireman, making it advisable to install some automatic system of fire control. This refinement, applied to installations of oil burners under steam boilers, is not yet well understood and an actual efficient installation is hard to locate. Such an automatic control is quite feasible, however, and the general principles involved are understood.

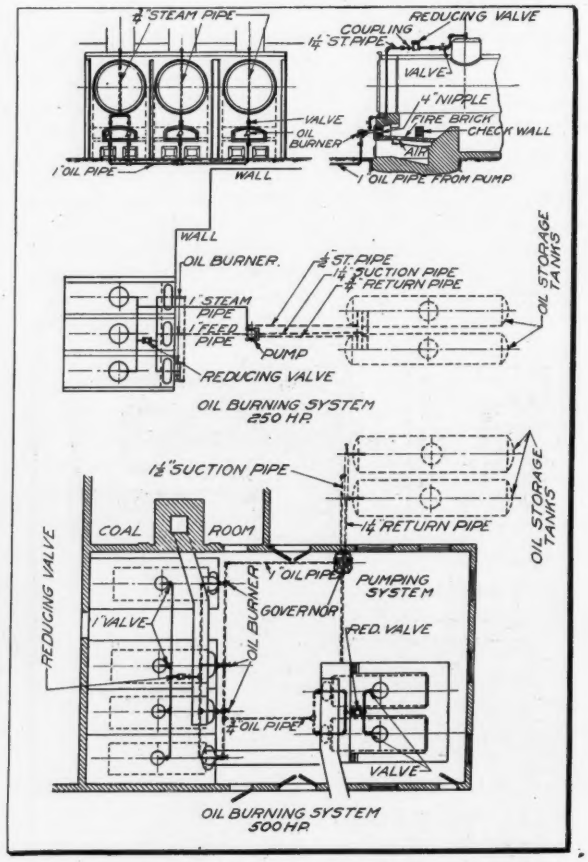


FIG. 6. PIPING PLANS FOR 2 OIL BURNING PLANTS

An increased load at constant engine speed—the condition desired—means a later cutoff for the engine and correspondingly an increase in the pressure of the exhaust. This increase in exhaust pressure may be utilized to increase the pressure of the oil supply as supplied to the burner, for if the discharge orifice of the oil burner is kept constant, an increase in the pressure at which the oil is supplied will have the desired effect of discharging more oil to the combustion chamber. This increase in oil pressure is then also made use of to actuate a diaphragm located in the oil supply pipe to the burner and controlling a system of levers operating on a rocker shaft damper. This form of automatic control gives a sensitive and reliable regulation, for any variation in load that may cause the operation of the engine governor will produce a corresponding difference in oil pressure and supply which will automatically regulate the admission of air to the combustion chamber, and thus realize the maximum efficiency of the boiler under all conditions of load.

HEATING AND VENTILATING LARGE BUILDINGS

Types of Radiating Surfaces

By Charles L. Hubbard

TYPE of radiator used and its location are often of as much importance as the proper size. The form almost universally employed in office buildings, hotels, etc., is the cast-iron sectional, of the general design shown in Fig. 1. This particular cut has been used because it illustrates a pattern of smooth finish, free from ornamentation, which is a desirable point to consider when selecting a radiator, both on account of appearance and ease in cleaning.

Depth and height should be chosen with reference to the position it is to occupy. In general, a 2-column radiator is more efficient than a deeper one, although 3 and 4 columns are often used where a shallow radiator would have too great a length. The height will be governed to some extent also by the location, but should be such as to give the radiator a good proportion. Those of large size may be of "standard" height, which is from 36 to 38 in., but for those

FIG. 1. COMMON FORM OF CAST-IRON SECTIONAL RADIATOR

containing under 40 or 50 sq. ft. of surface, a height of 28 to 32 in. gives a better appearance for the 2 and 3-column designs.

The logical place for a radiator is beneath the window, especially where these are of large size, as in the average office building. If placed at one side there is likely to be a disagreeable down-draft from the glass in cold weather. This also simplifies the arrangement of the risers, as they may be carried up on the wall or in covered slots between the windows, thus supplying 2 radiators on each floor.

The type of radiator shown in Fig. 1 may be used either for steam or hot water, as the sections are connected at the top. In the steam pattern they are connected at the bottom only, and therefore cannot be used for water. When water radiators are used for steam, on a single pipe connection, the best results are obtained by placing the air valve in one of the sections about two-thirds the length of the radiator from the supply end, rather than in the extreme end section, as is commonly done. In case of the regular steam pattern, the air valve should be placed in the end section about one-third the way up from the bottom.

A type of radiator especially adapted to small rooms such as toilets, etc., where it is desired to keep the floor free for easy cleaning, is the wall pattern, one section of which is shown in Fig. 2. These are adapted to either steam or hot water and are both efficient and convenient. Although used to a considerable extent in the larger sizes, their principal field is in rooms of comparatively small size requiring from 1 to 6 sections.

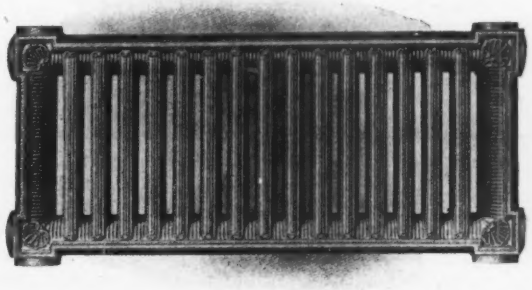


FIG. 2. SECTION OF WALL TYPE RADIATOR

In making changes or additions to the radiation in a building, the engineer commonly uses the same pattern which is already in use, but it is well to be familiar with certain points pertaining to their selection for different requirements, even under these conditions.

The indirect radiators most commonly used are of the "pin" or "fin" type, as shown in Figs. 3, 4 and 5. Figure 3 shows a single section of a pin radiator adapted to either steam or water. These are put together

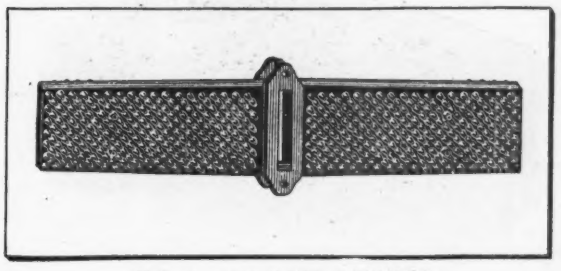


FIG. 3. PIN TYPE RADIATOR

with short bolts when making up the stacks, which makes it a simple matter to renew a single section, in case of repairs, without disconnecting the remainder of the stack.

Pin radiators are ordinarily made about 36 in. in length and in depths varying from 7 or 8 in. to 12 or 15; the shallower radiators being used for steam and the deeper for hot water.

A section of a deep radiator made especially for hot water is shown in Fig. 4, and illustrates the essential feature of radiators designed for this particular use:

that is, a continuous downward passage from the supply inlet to the return outlet; while it is true that practically all water radiators may be used for steam, the reverse does not hold unless the design is such as to provide for this particular feature. An assembled stack of indirect radiator sections is shown in Fig. 5.

An important point to be kept in mind, when using stacks of this kind, is to make sure that all spaces between them and the sides of the duct or casing are stopped off for the full depth of the sections. This is

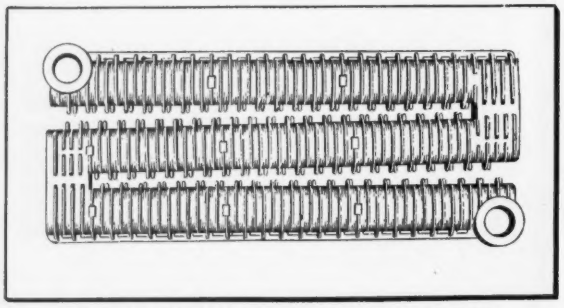


FIG. 4. SECTION OF HOT-WATER RADIATOR

especially important where they are supplied with cold air, as the currents will take the easiest path, which is by the stack rather than through it. The writer can recall a considerable number of instances where serious consequences have followed from the omission to provide these simple stops, and an inch space around an indirect stack may cut down its efficiency 50 per cent in some cases.

Secondary heaters, for re-heating the air from a fan, may be either of the direct or indirect type, according to their location and the form of the airway in which they are placed. When used in horizontal ducts, one or more direct radiators of the general form shown in Fig. 1 may be used, care being taken to use one of such general dimensions that the free area through it will be equal to the full area of the duct. In general, the free area between the sections in a radiator of this type

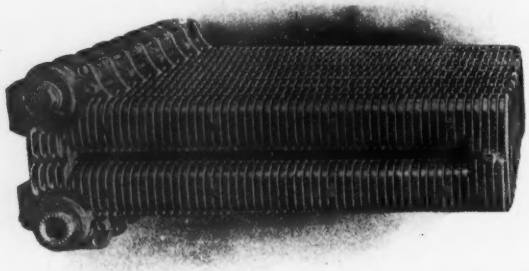


FIG. 5. ASSEMBLED STACK OF INDIRECT RADIATOR SECTIONS

is about 0.3 of the over-all area, so that by selecting the proper depth, the height and length can usually be made such as to give both the required heating surface and area for air flow. When the stack is placed in a vertical flue it is usually more convenient to use one of the general type shown in Fig. 5, as it can be hung in a horizontal position across the base of the flue. Here, as before, the free area through the stack must be sufficient to allow the air to pass through without too high a velocity. When a fan is employed, the velocity through the heater may be 600 or 700 ft. per minute without offering too great a resistance. With the ordinary form of indirect stack the free area may be taken as about 0.4 the over-all area.

A common form of main or primary heater for use with a fan is shown in Fig. 6. This is made up of loops of wrought-iron pipe screwed into cast-iron bases or

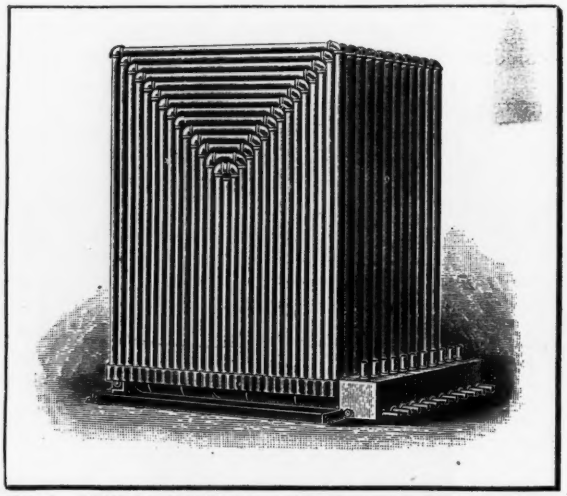


FIG. 6. COMMON FORM OF RADIATOR FOR USE WITH FAN

headers, each designed to carry either 2 or 4 rows of pipe. Pipe heaters vary chiefly in the design of the base and the method of removing the air and condensation.

They are provided with a steel casing, except in the larger sizes, where the building walls are made to take the place of this. A main heater made up of cast-

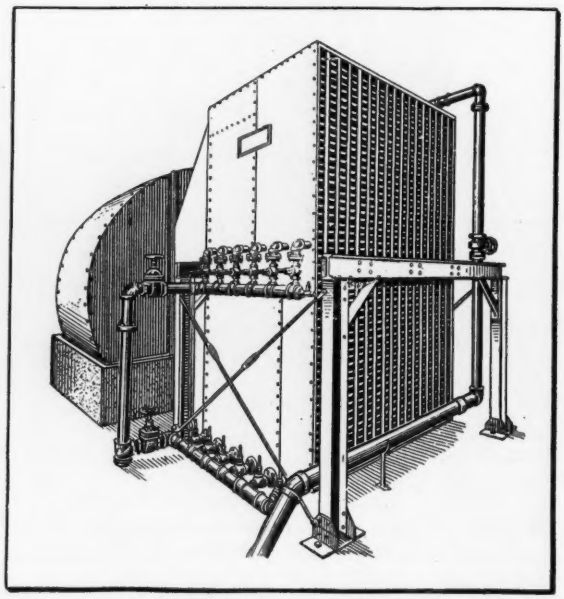


FIG. 7. METHOD OF INSTALLING RADIATORS FOR USE WITH FAN

iron sections placed in a vertical position is shown in Fig. 7. This type of heater is similar in action to the one just described, and is mounted and enclosed in a similar manner.

Main heaters are usually divided into several sections, the number depending upon the size, and each provided with a separate valve upon the supply and return. In making these divisions special care should be taken to arrange for as many combinations as possible. For example, a heater 10 pipes deep may be made up of 3 sections; one of 2 rows, and 2 of 4 rows each. By means of this division, 2, 4, 6, 8 or 10 rows of pipe can be used at one time as outside weather conditions may require. In making the pipe connections to a heater of this kind, a main or header is usually run along one side, from which branches of the proper size are carried to the different sections. The arrangement of the returns should correspond in a general way with the supplies. The main header should be properly drained and the condensation from the heater trapped to a receiving tank.

If possible, the return from each section should be provided with a water-seal 18 to 24 in. in depth. This is because condensation is greater in the outer sections, resulting in a slight difference in pressure, which causes the return water from the inner sections to be drawn into the outer ones, thus producing water hammer and imperfect circulation of the steam.

If the fan is driven by a steam engine or turbine, provision should be made for using the exhaust in the heater, and part of the sections should be so valved that they may be supplied with either live or exhaust steam as desired.

The amount of surface required to condense the exhaust from the engine will vary with the outside temperature, but about 50 sq. ft. should be provided for each indicated horsepower of engine for use in mild weather.

VERTICAL CURTIS TURBINES*

Hydraulic Valve Gear

HYDRAULIC operating mechanism of the turbine consists of a cylinder to which oil under pressure is fed through a pilot valve under the control of the turbine operating governor. The piston rod of this cylinder carries a rack which meshes with a pinion on the cam shaft, and so actuates the shaft. The cams on the cam shaft lift the individual controlling valves as determined by the angular spacing of the cams.

Governor control is secured by means of a light rod from the end of the governor beam to one end of the floating lever. This floating lever is pivoted on a clamp attached to the pilot valve stem. The other end of the lever is connected by links to the piston rod of the operating cylinder. A movement of the governor beam displaces the small pistons of the pilot valve from their normal location in which they close the ports of the cylinder.

This displacement causes oil to be admitted to the cylinder, and this operates the main piston. The piston rod in turn through the cam shaft opens or closes the

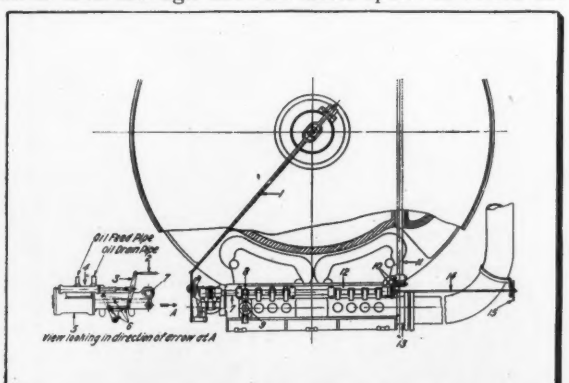


FIG. 8. ARRANGEMENT OF HYDRAULIC NOZZLE CONTROL GEAR

1 Governor beam; 2 Governor connection to floating lever; 3 Floating lever; 4 Pilot valve chest; 5 Hydraulic cylinder; 6 Differential mechanism for floating lever; 7 Cam shaft with pinion; 8 Cam with key and set screw—give position; 9 Controlling valve; 10 Miter gears for (7) and (11); 11 Cross shaft; 12 Cam shaft bracket with caps; 13 Valve casing; 14 Indicator shaft; 15 Indicator.

controlling valves, and at the same time through the link system transmits its motion to the end of the floating lever and thus brings the pilot valve back to its normal position. Thus each position of the governor determines a definite position of the piston in the operating cylinder and consequently the opening of a definite number of controlling valves.

In setting the gear with the governor dead, all the controlling valves should be open, the last roller just crowning its cam, and the piston of the operating cylinder at the end of its opening stroke. The pilot valve should be dropped by hand to make sure that the piston of the operating cylinder will close all the controlling valves without jamming the rollers on the backs of the cams. The gear should then be tried out under the control of the governor, and any slight

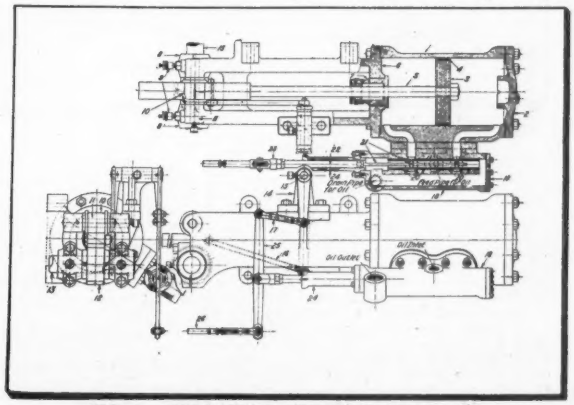


FIG. 9. HYDRAULIC CYLINDER AND PILOT

1 Operating cylinder; 2 Cylinder head with studs and nuts; 3 Piston; 4 Piston rings; 5 Piston rod and rack with nut; 6 Supporting bracket for (1) with bolts and studs; 7 Stuffing box with gland and nut for (6); 8 Bearing caps for (6) with bolts; 9 Lubricators for (8); 10 Guide roller for rack; 11 Spindle for (10) with pins and grease cup; 12 Pinion for cam shaft with key and set screws; 13 Cam shaft; 14 Bracket for differential mechanism with lubricator and bolts; 15 Rock shaft and levers for differential; 16 Differential connection rod to rack with pins; 17 Differential connection rod to floating lever with pins; 18 Pilot valve chest with bolts; 19 Cover plate for chest with bolts; 20 Bushings for pilot valve chest—locate definitely; 21 Pilot valve; 22 Connecting rod for pilot valve with nut; 23 Clevis for (22) with lock nut; 24 Guide bracket for chest with nuts; 25 Floating lever with pins; 26 Governor connection rod and pins.

excess of the governor travel over that required to actuate the operating or main piston should be divided equally between the 2 ends of the stroke.

Controlling Valve

STEAM is admitted to the first stage nozzles through controlling valves. These valves are of the globe type and are free on their stems to permit them to seat properly. The stem extends through a stuffing

*Concluded from page 258, March 1 issue.

box, and is secured to the lower guide plate of the spring. This spring is supported by a bracket, and is compressed, by an adjusting screw at the top, sufficiently to force the stem through the stuffing box and seat the valve. The bracket also supports one end of a lever, the other end of which is fitted with a roller which rides over a cam on the cam shaft.

Two short ball ended thrust pins connect the lever to the lower spring support. The upper recesses for these pins are made sufficiently deep, so that the pins cannot fall out of place in case the guide plate sticks with the spring under compression and the controlling valve lever properly follows the cam in a downward direction.

Cam shaft, which is rotated by the rack at the end of the piston rod of the hydraulic cylinder, is supported by a bracket bolted to the steam chest. The cams are so arranged on the shaft that they raise and lower the valves in succession.

Care should be taken to see that all bearings are properly lubricated, and that the valve stems move freely through the stuffing boxes, that the guide formed

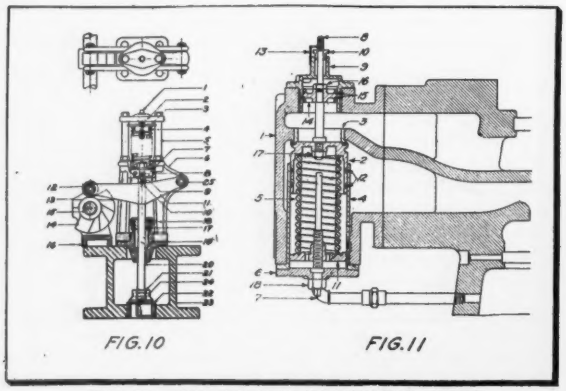


FIG. 10. SECTION OF CONTROLLING VALVE
FIG. 11. AUTOMATIC STAGE VALVE

1 Adjusting screw for valve spring; 2 Supporting plate for (1); 3 Spring supporting plate (adjustable); 4 Controlling valve spring; 5 Stud for spring supporting plate, with nut; 6 Frame for controlling valve, with bolts; 7 Guide plate for valve stem; 8 Upper cup for (7); 9 Thrust pin; 10 Lower cup for (11); 11 Controlling valve lever; 12 Cam roller for lever; 13 Spindle for cam roller with nut; 14 Cam with key; 15 Cam shaft; 16 Cam shaft bracket with bearing cups and bolts; 17 Gland for packing; 18 Nut for stuffing box; 19 Guide plate and stuffing box for valve stem; 20 Valve stem; 21 Valve (wing type); 22 Valve seat; 23 Valve casing; 24 Pin for (20) and (21).

1 Casing for automatic stage valve; 2 Valve and piston; 3 Valve seat; 4 Cylinder lining; 5 Spring; 6 Cylinder head; 7 Adjusting screw; 8 Indicator rod; 9 Balance cylinder lining; head and stuffing box for (8); 10 Gland for (9); 11 Spring support; 12 Piston ring for (2); 13 Indicator; 14 Balance piston; 15 Piston ring for (14); 16 Clamp nut for (14); 17 Clamp nut for (2); 18 Lock nut for (7).

by the upper end of the bracket for the lower guide plate of the spring is properly lubricated, and that there is sufficient compression of the spring to force the valve to its seat.

Stage Valves

IN most of the multistage vertical turbines, automatic valves are provided which open additional second-stage nozzles at times of overload. Most of the valves of this kind which have been used have been arranged as shown in Fig. 11, to open by the effect of increased pressure in the first stage. These valves are balanced by a spring and are so proportioned that they tend to open and close again with a comparatively small range of first stage pressure.

These valves can be adjusted to operate at various pressures, and different adjustments may be desirable for the best average economy under different load conditions. No positive rule can be given for these adjustments, since different pressure distribution suits different machines.

If the adjustment of these valves is such that one or more of them tends to remain partly open during considerable ranges of load, the economy of the machine may be seriously impaired, or if one of these valves becomes stuck in a throttling position it may impair economy at all loads. They should open and close abruptly and in succession. These valves are intended to open abruptly as soon as the corresponding first-stage valve is open.

FEED-WATER SYSTEM IN LARGE PLANT

Boiler Feed-Water Piping at the West Tenth Street Power Station of the Terre Haute, Indianapolis & Eastern Traction Co. at Indianapolis, with Special Reference to the Injector System

BY CHAS. HOGATE

THE boiler feed-water system in service at the West Tenth Street Power Station of the Terre Haute, Indianapolis & Eastern Traction Company has some original features that are radical departures from customary practice in this particular phase of power plant design. The boiler plant consists of 12 520-hp. Babcock and Wilcox water-tube boilers with superheaters, delivering steam at 180 lb.

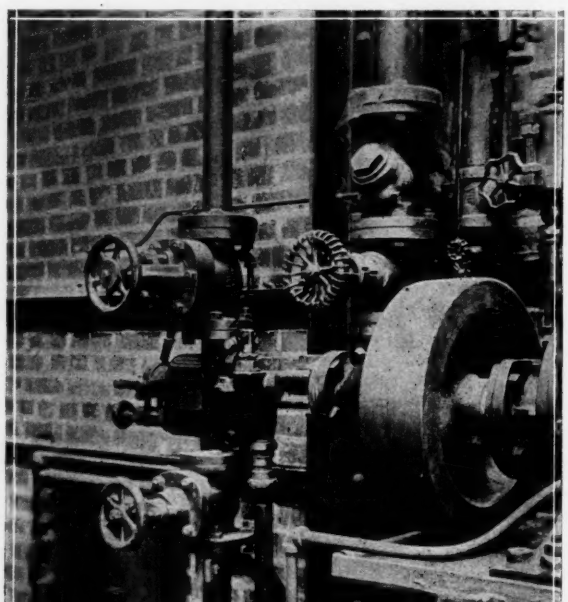


FIG. 2. CLOSE VIEW OF INJECTOR SHOWING CONNECTIONS

pressure and 100 deg. F. superheat, arranged in 2 rows of 10 and 2, back to back, with a radial brick chimney 18 by 320 ft. between the rows and space for 8 more boilers on the second row. The boiler room has a 20-ft. basement in which the boiler feed and service water pumps, drain pumps, sump pumps, etc. are located. The feed-water lines, the main steam headers and other smaller auxiliary piping are

also in the basement. These lines are arranged with large clearances and are easily accessible for repair or extensions.

Under normal operating conditions, the boilers are fed by 2 duplex, double plunger, outside packed 20 by 14 by 24-in. steam pumps supplying water from 2 6000-hp. Cochrane feed-water heaters located on the boiler-room floor directly above the pumps. One pump supplies enough feed water, under ordinary load conditions.

These pumps discharge through 2 10-in. cross headers into 8-in. double or loop headers extending full length of each row of boilers and located approximately under the front line of the boilers. The arrangement of the valves in the 8-in. loops and the 10-in. cross headers allows either half of one or both loops to be supplied from either pump, so that repairs can be made on one of the pumps or at any point in lines without interrupting the service.

connections being 2½-in. diameter, with 2-in. diameter overflow pipe. The capacity is about 4000 gal. an hour with 175 lb. steam pressure or 500 to 650 hp. on the basis of 30 lb. evaporation per hp.-hour.

Feed water is supplied by 2 14 by 14 by 18-in. duplex steam pumps from a 16-in. suction line drawing water from the intake conduit, which extends under the turbine room from the river. These pumps discharge into a cross header, which supplies 8-in. lines running under the 2 rows of boilers and from which the 2½-in. supply lines to the injectors are tapped out.

These pumps also supply a 50,000-gal. tank at 100 ft. elevation outside of the building which is allowed to float on the injector line at all times.

The temperature of the injection water varies from 75 deg. F. during the summer to as low as 35 deg. F. in the winter months. This is, of course, increased 10 to 15 deg. F. by the addition of steam at the injec-

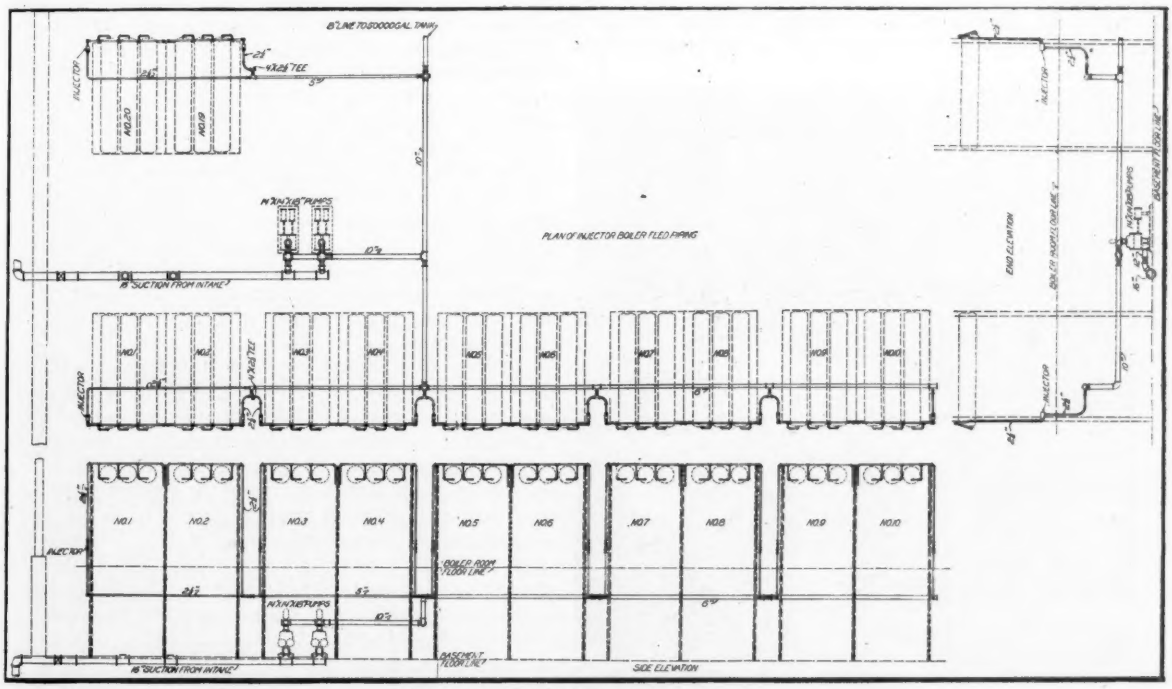


FIG. 1. FEED-WATER PIPING SYSTEM

From each side of the 8-in. loops 2½-in. lines are run up through the floor in front of the boilers with globe and check valves above the floor. These 2 lines converge into a single line, which is tapped into the front of the boiler drums. Each boiler is equipped with a Williams feed-water regulator, although the boilers may be fed by hand if conditions require it.

About 200 lb. pressure is carried on the feed lines at a temperature around 200 deg. F.

In addition to the system just described, there is another complete feed-water system which is operated independently of the first, consisting of complete injector equipment at each boiler with separate water mains and pumps and an independent steam header, supplying the injectors.

The injectors are Metropolitan, model "T," manufactured by The Hayden and Derby Company. All pipe connections are flanged, the water and steam

tors. In either case, the injector feed-water temperature is quite considerably lower than the high pressure feed-water temperature and if fed into the boilers would result in the immediate loss of steam. Also the amount of steam used by the injectors would cause a drop in pressure.

The general arrangement of the headers and valves is similar to the high-pressure feed piping, except that the injector system has a single line instead of the loop under the boilers.

Steam for the injectors is supplied by an independent 2½-in. saturated steam header running along the top of the boilers and tapped out at tees located between the safety valves and the flanged necks on the drums for safety valve connections, on the saturated steam side of the boilers. Supply lines run down to each injector from this header. The arrangement of valves in this header is such that any boiler may be cut

off. The overflows are piped into a common drain line which discharges into the river.

The most important advantage of the injector system is, that it will immediately pick up and carry the load in case of a critical failure of the boiler feed pumps or any part of the high-pressure system, so that the station service would not be interrupted. In this event, an additional boiler would probably have to be put into service to supply the additional steam required by the injectors, and the boilers fired heavily until the tendency for loss in steam pressure would be overcome.

Steam for the 2 boiler-feed pumps and the 2 service pumps is supplied by a 6-in. loop header, either half of which will supply the pumps while the other half is cut off. In case of a complete failure of this loop, the 50,000-gal. tank, maintaining a pressure of 50 lb. on the injector water lines, could be depended upon, in the emergency, for at least one hour's station operation.

At light load the injectors require little steam. During the period of light station load at night they are often used in preference to the high-pressure feed,

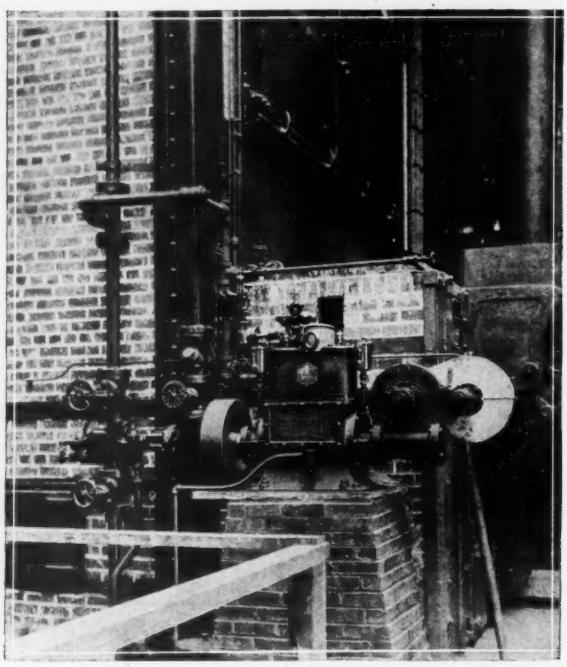


FIG. 3. FEED-WATER PIPING SHOWING INJECTOR LOCATION RELATIVE TO BOILER

because the steam pressure is more easily regulated on the boilers that have to be kept under fire ready to pick up the heavy early morning load.

When a boiler has been down for repairs or inspection, the injector is used to re-fill it. If this amount of water were taken from the high-pressure feed lines, it would almost drain the heaters and interrupt the uniformity of service.

Also the injectors are used occasionally when minor repairs have to be made on the live steam or exhaust lines to the boiler-feed pumps.

Another use is to keep the steam pressure from rising too rapidly in a boiler that is being fired up ready to put into service.

The photographs show the typical injector equipment and location relative to the boiler, together with piping. The vertical lines above the injector are the 2½-in. steam supply, the vertical line below, the 2½-in. water supply. The 2½-in. discharge to the boiler is shown to the right, running up the front boiler column.

The complete injector system with arrangement of pumps, cross-headers, feed-headers, valves, sizes of pipes, etc. is shown by the drawing. Plans were originated and worked out in detail in the office of the chief engineer of power stations.

THE ISOLATED PLANT WINS

By Joshua O'Leary

IN the issue of Jan. 15, a writer criticises the article on "The Isolated Plant Wins" which appeared in the issue of Oct. 15, 1912; but as this criticism is based on an entire mis-apprehension of the facts in the case it may be permissible to point out briefly the error into which his zeal in behalf of the central station seems to have betrayed him. At the outset he indulges in some strictures on the engineers of the isolated plants, to whom he imputes, among other shortcomings, deflection from good form in discussion, as well as failure to "meet the matter squarely" in dealing with the claim of the central station to superior advantage and economy. These strictures, however, do not call for serious refutation. They may have been meant only in a Picwickian sense, or, to borrow from our old friend "The Mikado"—they may have been designed merely "to give verisimilitude to an otherwise bald and unconvincing narrative." But getting down to facts, as he apprehends them, in the article criticised he says:

"Only two of the expense items are given in the article, but analyzing those for February we find the fuel per kw. cost $0.0205 and oil and waste $0.0016. Though it is not so stated we must assume that some one is in attendance 10 hours a day and 6 days a week and in addition, some overtime for cleaning and repairing, and as it appears the engineer is to be classified as a professional man and would at least be entitled to $75 a month and do all the work of the plant from handling the coal in to watching the kilowatts out. This would add to the operating costs $0.0293 per kw. hr. He should not be required to act as foreman oiler and all-round plant man and perhaps he does not; however, the article does not consider the labor item in operating costs and we have assumed it at a figure low enough to give the isolated plant the benefit of any error on our part."

In the article of Oct. 15, there occurred a paragraph which it would seem ought to have obviated any necessity for "assuming" that an engineer was in attendance. Speaking of the engineer it says:

"Not having the fear of the great corporation in his heart, he began at an early date to collect and record data bearing on the question of cost. He took daily readings of the meters; weighed and recorded daily the amount of coal consumed for heating purposes, and kept systematic and accurate account of all items of expense in his department. As a result he soon satisfied himself that the service rendered by the outside corporation could be secured at much less cost if he could induce his employers to install their own plant, and to this task he addressed himself with intelligent persistency and final success."

In view of this explicit declaration concerning the engineer's attendance and significant activity it is hard to understand how the assertion "though it was not so stated, we must assume that someone is in attendance, etc." can be justified. This shows, moreover, that the heating plant, with its attendant expense of operation and maintenance, subsisted throughout the whole period covered by the contract with the central station. Obviously the comparison instituted had reference only to the electric service supplied by the competing plants, it would therefore have been absurd to have loaded the case of the local plant with a heavy bill of expense that had nothing whatever to do with it. Surely neither good form, nor devotion to the principle of the square deal required that unrelated items of expense should be introduced in the comparison when compensating factors of heating and other services were omitted. The fixed charges for installation maintenance and operation of the heating plant were not introduced in the comparison for the simple but sufficient reason that they had no relevancy to the cost of either the central station service or the equivalent service supplied by the isolated plant. All the items of expense mentioned, even to the "risk to the owner of a serious defect showing up in a boiler" were borne by the plant during the term of the contract, in addition to the cost of service by the central station, and they continued practically unchanged after the installation of the local service.

As to the cost of installing the additional equipment, that is quite immaterial as after allowing for "interest on the investment, insurance, depreciation and repairs" it was shown that there was a net saving of 50 per cent of the cost of the central station service.

Regarding the claim of capacity to meet increase of service, if required, without increase of cost, that was clearly intended to apply to fixed charges of operation which our critic himself acknowleges "would remain constant for quite an increased load."

Concerning the objection that "In this case the central station rate is excessive and this would be a profitable day load at less than half the 9-cent rate" it is enough to say that the rate mentioned was the rate charged during the whole period the contract was in force, and was therefore properly used in the comparison. That it was not deemed excessive by the management of the central station is indicated by the refusal, as stated, to reduce it while there was any prospect of its continuance for another term. But does not an attorney for the central plant prove altogether too much when he points out the fact that an excessive rate is one of the disadvantages that may be encountered in dealing with the central station?

The data, as given in the article of Oct. 15 were facts developed in the actual experience of the isolated plant referred to, and the comparison was with the actual cost of the service rendered by the central station. The results were exactly as stated, and they are unaffected by any assumptions as to what they would have been had the conditions been different from what they were. As a matter of fact, however, the experience of the plant referred to is not exceptional. It is common knowledge among well informed engineers that in any case in which it is necessary to keep a boiler plant in operation for heating and other purposes, electric service can be supplied at a cost with which the central station cannot successfully compete on its merits.

ISOLATED PLANT COST

By A. K. Vradenburgh

COMMENTING on the article by Mr. Reynolds why should he add to the cost of electric light the cost of a man in attendance since one is already on the the ground when the heating plant is in service and also the power to run the hydraulic elevator and other machinery? I believe that his estimated cost for the electrical installation of $10,000, which he believes small is amply large, as the stack is already in place and the distribution portion of the switchboard. All the installation such as furnace, flue cleaners, gaskets, gage glasses and the expense of hauling away ashes and so on are already accounted for in the expense of heating the building, so that the only additional expense chargeable to the lighting is the necessary care of the generating equipment and the generator portion of the switchboard.

But a little recapitulation will show that even with the cost estimated, and that is plenty, the argument is still in favor of the isolated plant. Take for fuel, oil and waste, the cost per kw.-hr. of $0.0231; interest, depreciation on the estimated $10,000 cost, with 2 per cent added for taxes, $0.0319 per kw.-hr.; total cost per kilowatt-hour $0.0540, which is $0.0360 less per kilowatt-hour for the isolated plant current than for the central station current. This multiplied by 3133 kilowatt-hours gives us $112.78 a month or $1353.45 a year saved, which is nearly 14 per cent on the estimated first cost of $10,000; not a bad investment at that.

As for the advantages of central station service, the private plant where the writer is employed has been in operation for a little over 6 yr. and the power and light have not been interrupted 5 min. when they were needed during that time. On the other hand, when current was being supplied by the central station, it was a common occurrence for the service to be interrupted from 5 min. to 2.5 hr. at a time. During the past 8 months the current from this same central station has been off throughout the whole city 1 hr. 20 min. and 2 hr. 20 min. respectively. During these periods of suspension we had no trolley cars, electric light nor anything else requiring electricity for operation, yet the writer tries to tell us about the advantage and economy of this kind of service. Without going into details, I would state in closing that the current which costs us $5500 to buy, we generate in our own plant for $3500, to say nothing about the better service.

The grade of pipe known as Merchant, which is lighter in weight than standard, is not suitable for many purposes, but has been used in the past on account of somewhat less cost.

Following the example of the National Tube Co., practically every popular mill has announced that the manufacture of Merchant weight will be abandoned, thus leaving only full weight pipe on the market and pipe which will be suitable for all purposes for which the Merchant weight has been used.

This is a distinct advance in pipe manufacture, as it does away with 2 grades, one of which was not a standard and leaves a single, dependable, high standard pipe as the one which will be used in every case. The pipe using public is to be congratulated on the forward step which has been taken in its behalf by the manufacturers.

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

ST. JOSEPH'S COLLEGE STORAGE BATTERY PLANT

An Interesting Installation of Storage Batteries Which Aids the Generators During Peak Load and Furnishes Current During Off Peak Load; Details of Installation and Equipment

By H. Olberding

STORAGE battery installations as auxiliaries to private plants, for taking care of peak loads or for carrying the entire load in off peak hours, have proved to be of considerable advantage, and details of the power plant in St. Joseph's College, Rensslaer, Ind., of which the writer is in charge, will undoubtedly prove of interest.

The plant consists of 2 horizontal tubular boilers, 66 in. by 16 ft. and one horizontal tubular boiler, 72 in. by

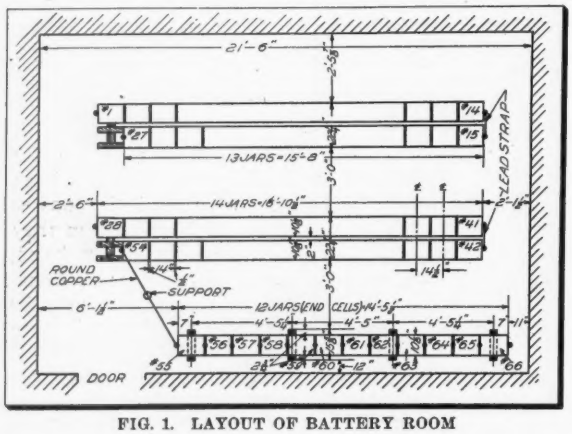


FIG. 1. LAYOUT OF BATTERY ROOM

18 ft., with a combined rated capacity of 350 hp. The boilers are operated at 90 lb. steam pressure, the greatest load being required for heating purposes. In the auxiliary boiler room equipment are 2 Gardner 6 by 4 by 6 in. duplex boiler feed pumps and 2 Gardner 8 by 12 by 7 by 12 in. compound duplex pumps for domestic purposes and fire service. The lighting plant comprises one Ames automatic 10 by 12-in., and one 8 by 8-in. engines, belted to a 30-kw. and a 15-kw. Western Electric direct-current generator respectively delivering current at 115 volts.

In connection with these units, a 320-ampere-hour storage battery has been installed, manufactured by the Electric Storage Battery Co. It is of the chloride accumulator type, installed about 4 yr. ago and consists of 66 cells with 4 positive and 5 negative plates. Its rated capacity is 40 amperes for 8 hr. at 115 volts.

The reason for installing a storage battery in connection with the generators was because the load during the night hours is rather small so it would not warrant the running of an engine all night with the expense of an attendant and the wear of running machinery. This being an educational institution the electric load is practically the same every day. The smaller unit is operated a few hours every morning, until the load drops to about 40 amperes, when it is stopped and the battery put into service until noon, when it is generally so far exhausted as to make charging necessary. The large unit is then started again charging the battery and at the same time furnishing current for the day load, until about 5 or 6 p.m., the battery is fully charged and cut out; the engine is kept running as the peak load comes on about this time and is run until 9 p.m., when the load

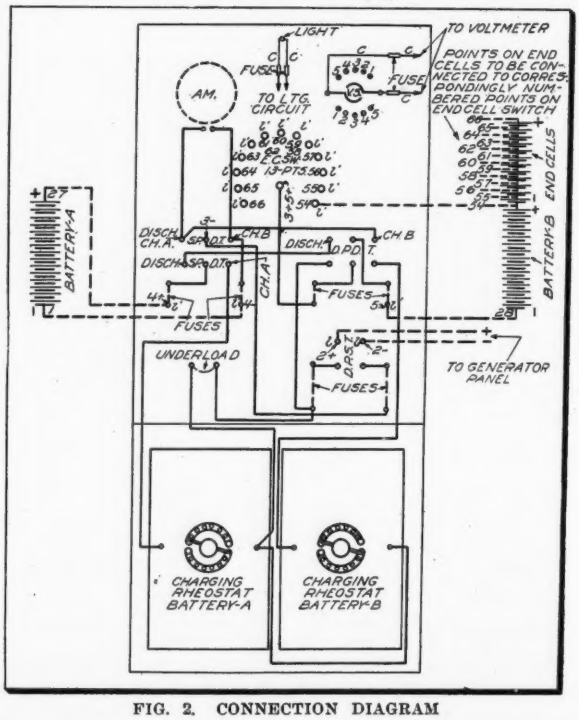


FIG. 2. CONNECTION DIAGRAM

again drops low enough for the battery to take care of until the following morning at 5:30, when a similar cycle of operations is started.

Battery Room and Battery Support

AFTER the type and size of the storage battery had been decided upon, the first step was to select a place where it could be properly installed. A room next to the engine room, 15 by 22 ft. by 12 ft. high, was selected. The floor was made of concrete and given sufficient slope for water to run off into a tile when the floor is washed. The ceiling was carefully plastered to prevent the fumes

from entering the apartments above, and proper means to secure ventilation were provided. This is important, as the fumes are strong and destructive, especially on the day of the overcharge, besides, these fumes are of an explosive nature and an open flame should never be allowed in a battery room.

When the room was in proper shape the work of installing began. Wooden frames or racks built by the Battery Co. were installed; they are 16 in. high and made up of 4 by 4-in. timbers painted with 2 coats of asphalt paint and sufficiently strong to sustain the weight. Each cell weighing 200 lb. was set in place, the legs resting on vitrified brick. Three sections of racks were necessary, 2 to carry each 2 rows of 13 and 14 cells respectively and one to support one row of 12 cells. Figure 1 shows the layout of the battery room. Such an arrangement of racks and cells permitted an alley 2 ft. 6 in. wide between the wall and each double row of cells, while the single row is placed next to the wall, but can be approached on one side, thus making it convenient for inspection and repairs since each cell can be handled separately.

Installation of Battery

AFTER the racks were erected and in their proper places, wooden trays, just large enough to accommodate one cell, and about ¾ in. deep, were filled level with sand and placed on the racks, spaced equal distances apart and insulated from the racks with glass insulators, then the empty glass jars, that were to contain the elements, were placed on the sand trays. Great care was exercised to get them level and in straight line to present a neat appearance. The dimensions of the jars are 9 by 12 by 17 in.

The elements were shipped assembled and all that remained to be done was to take them out of the boxes and place them in the jars. A strong strip of cloth was passed below and around the plates and by taking firm hold of both ends at the top, the whole was gently lowered into the jar.

Extreme care was taken during this operation not to injure either the plates or the jars. The positive terminal of one cell was always placed next to the negative terminal of the adjoining cell so that no more handling was necessary.

Connecting Up and Filling

WHEN all the elements were in place the terminals were bolted together with brass bolts, having previously received a slight coat of vaseline, the nuts on either end being imbedded in a large lead cap. The 2 cells at one end of each double row were connected by means of a lead bar. While heavy lead covered copper wires were looped across the alley from one rack to the other, sufficiently high to permit passing under them; these were firmly soldered into lugs provided for that purpose at the proper terminal.

Twelve cells along the wall were all provided with lugs, clamped between the terminals of each cell and bolted firmly; a rubber covered wire was soldered into each of these lugs and then passed directly through the wall and over to the switchboard, where it was connected to the end cell switch as shown in the connection diagram, Fig. 2. When all connections had been made they were all looked over carefully once more to make sure that all were in their proper places.

Next came the work of placing the separators between the plates in the cells, which are made of thin sheets of specially treated wood a little larger in size than the plates; dowel pin, also wood, is slipped on at each end to hold them in place. Glass bars are laid over them across the plates to hold them down. The separators and dowel pins had not been removed from their boxes, and had been packed in such a manner that they could be kept moist easily to prevent drying and warping.

A small platform was made of a few trusses and planks at a convenient place outside and next to one of the windows of the battery room. An empty spirits barrel had been obtained sometime before, which, sawed through the middle and one of the halves placed on the platform, brought the bottom of the half barrel a little

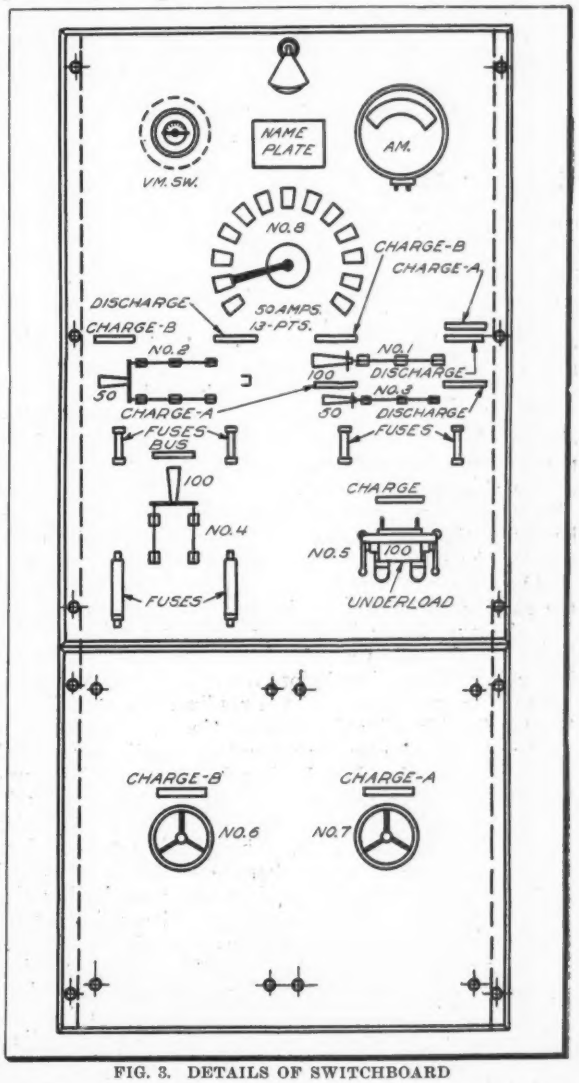


FIG. 3. DETAILS OF SWITCHBOARD

above the top of the cells in the battery room. This was then filled with electrolyte of 1.210 specific gravity. Most readers will know that this is dilute sulphuric acid about 1 part acid to 5 parts water, which was furnished ready mixed by the Battery Co.

One end of a new ¾-in. rubber hose was immersed into the acid in the half barrel and the fluid syphoned into each cell, the barrel being refilled as fast as emptied.

All cells were filled with ease in a comparatively short time without any accident to the cells or to those doing the work. Up to the time of putting in the separators and filling in the electrolytes, the task of erecting and connecting up had been done by local help with the writer as engineer in charge, directing the work, but from that

time on a competent man furnished by the Battery Co. was present. In company with him everything was gone over once more, carefully inspected and tested, and nothing wrong being detected, the initial charge was started immediately and continued for about 60 hr. without interruption.

During the charge the specific gravity of the acid was tested at regular intervals by means of a hydrometer and the readings recorded. Voltage readings of the different cells were taken with a low reading voltmeter and also recorded. When the specific gravity and voltage readings did not show any further increase for 10 hr. successively and all cells were gassing freely, the charge was stopped and the battery put into service and it has given the best of satisfaction with practically no expense for repairs up to the present time.

Pilot Cell and Accessories

CELL No. 53 was chosen as the pilot cell, as it was easily accessible and near to the entrance. This is equipped with one ordinary and one compensating hydrometer. An automatic waterfilling device keeps the electrolyte at the proper level so that accurate specific gravity readings may be obtained. All of the other cells are refilled once a week with pure water to replace evaporation. The pilot cell is also provided with a signaling hydrometer which rings a bell and lights a lamp when the battery is discharged or fully charged.

This is particularly convenient and prevents over discharge when a heavier demand than usual is placed on the battery. The device can be set to ring at any time of the charge and discharge. In this case it is set to give a signal when the battery is a little over ¾ exhausted. Specific gravity readings of the pilot cell determine the limit of charge and discharge.

Once a week, usually on the day of the overcharge, the specific gravity of all the cells is taken, shortly before the overcharge is started; while the voltage readings of all the cells are taken from time to time at longer intervals, and then just before the overcharge is stopped. All specific gravity and voltage readings are recorded on blanks, furnished by the Battery Co.

As all cells are numbered and the readings recorded in the space on the blank having the corresponding number, it is an easy matter to detect any irregularity in any one cell by simply comparing the present reading with that of the preceding week. The overcharge is, in fact, the same as any ordinary charge, only it is prolonged until the specific gravity readings show no further rise for 5 successive 15-minute readings. When using a common hydrometer, corrections must be made for changes in temperature, 70 deg. being normal. For every 3 deg. F. above 70 deg. one point specific gravity must be added to the reading, and for every 3 deg. below 70 deg. one point specific gravity must be subtracted from the reading. When a compensating hydrometer is used this is not necessary, because it adjusts itself to changes in temperature.

Charging

THE battery is charged in parallel, that is, it is divided into 2 series, each series being charged at the normal rate of 40 amperes. This arrangement brings the total charging current up to 80 amperes, twice its rated output. The regular charge is brought up to a point when the specific gravity in the pilot cell shows about 5 points less than the preceding overcharge and all cells are gassing moderately. For example: If the preceding overcharge shows 1.190 points specific gravity, then the regular charge should be 1.185 points specific gravity, corrections for changes in temperature having been made.

Battery Switchboard

SWITCHBOARD panel is made of black slate 6 ft. 6 in., high, 3 ft. wide and 1½ in. thick, and the following instruments are mounted on the front: One 5 point voltmeter switch which permits using one voltmeter for both generators; one Weston double scale 80-80 amp. ammeter controlled for charge and discharge by ammeter switch No. 1; one d.p.d.t. switch and one s.p.d.t. switch Nos. 2 and 3, for throwing battery into parallel series for charging or in series for discharging; one d.p.s.t. No. 4 switch to generator or line; one automatic underload circuit breaker No. 5, having mercury contact, which trips automatically should the charging current from any cause drop to a certain point, in this case about 50 per cent below normal, or fail altogether, thus preventing injury to battery due to undercharging, also to prevent the current from the battery going into generator should it for any reason stop during the charge.

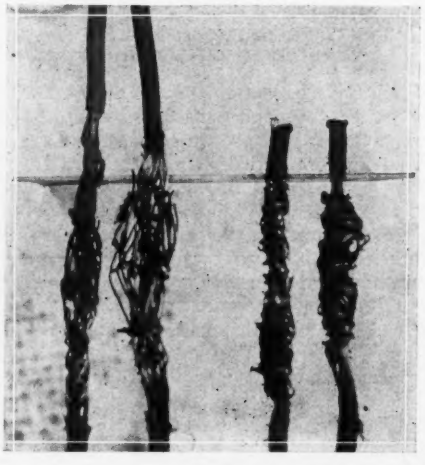
Nos. 6 and 7 are handles for charging rheostats which bring the current to normal charging rate; No. 8 is a 13 point, hand operated end cell switch, by means of which additional cells may be thrown into service as occasion may demand, to keep the voltage normal during discharge. Four 60-amp. and two 100-amp. enclosed fuses complete the outfit.

WHAT INSPECTOR DIDN'T SEE

By L. M. Johnson

SOME time ago we had occasion to renew some cables leading to another building. There were 2 pairs of 400,000 c.m. cables that had been spliced just before going through the wall into the street. As these splices were big knots in the cable, the cable was cut off on each side of the knots.

One day I stripped the tape off the splices; and the accompanying photograph shows what I found under the tape. The 2 closely twisted connections had been in service about 8 or 9 yr. and were soldered. The 2 large connections which had been in 5 or 6 yr. were not soldered; the end of each wire was made into hooks and hooked to another wire on the opposite cable, the connection being a mass of hooks.



JOINTS THAT THE INSPECTOR DIDN'T SEE

The tape that was taken from the 4 connections nearly filled a peck measure. I was told that the connections were made by the superintendent of the building and the house carpenter.

PRACTICAL ELECTRICAL ENGINEERING

Calculating the Pull of Magnets, Temperature Rise, Heating Loss and Ampere Turns Required

PULL in pounds or the weight that a direct-current magnet will lift when its core is in contact with iron or steel is determined by formula (I) in "Symbols and Formulas used in the Design of Electromagnets" in the Practical Reference Tables. It states that the pull in pounds is equal to the product of magnetic density per square inch, squared, and the area of the core in square inches, divided by 72,134,000. As an example, assume a core area of 2 sq. in. and a magnetic density of 100,000 lines of force to the square inch, then we have $(100{,}000 \times 100{,}000 \times 2) \div 72{,}134{,}000 = 277$ lb. pull.

Formula (II) is derived from formula (I) and is used to determine the required area of the core; this is equal to the product of 72,134,000 and the pull in pounds, divided by the magnetic density in lines of force to the square inch, squared. Assume that pull required and magnetic density have the same value as in the last example, then $(72{,}134{,}000 \times 277) \div (100{,}000 \times 100{,}000) = 1.9$ in. area of core. If the pounds pull in the previous example had been carried out to an indefinite number of decimal places we would have 2 as the answer which would be absolutely correct.

Formula (III) states that the square of the magnetic density per square inch is equal to the product of the pounds pull times 72,134,000, divided by the area of the core in square inches, then using the same values as in the previous examples we have $(277 \times 72{,}134{,}000) \div 2 = 9{,}990{,}559{,}000$, the square of the required magnetic density per square inch of core area.

Here again if the decimal had been carried out far enough in the first problem the magnetic density squared would be 10,000,000,000, and the square root would be 100,000, the assumed value in the first problem.

Formula (IV) gives the true value of magnetic density instead of the square and the operations are the same as in formula (III) with the exception that the square root of the solution is extracted.

Heating of Magnets

IN designing small magnets such as those used for telephone, telegraph and electric bell service, the heating of the magnet is not considered in the calculations, but in power magnets the temperature rise is important and should not exceed 212 deg. F. above atmosphere; it is calculated by the use of formula (V) which states that; the temperature rise in degrees F. is equal to the constant C multiplied by the quotient arising from the division of the power in watts expended in the magnet by the cylindrical surface of the magnet in square inches. The constant C is 200 for open magnets, i. e., with winding exposed to the air.

Assume that an open electromagnet has an outside cylindrical surface of 37 sq. in. and the watt loss ($I^2 R$ in direct-current magnets) is 38.9, then the final temperature rise will be $200 \times (38.9 \div 37) = 210$ deg. F.

If we know the final temperature rise and the cylindrical surface and wish to find the safe watts loss we use formula (VI) which states that the watt loss is equal to the product of the final safe temperature rise and the cylindrical surface in square inches divided by the constant. Let temperature rise and surface have the same value as in the last problem, then $(210 \times 37) \div 200 = 38.8$ watts.

Assume that the watt loss and temperature are the same value as in the previous problems and we wish to know the required cylindrical surface of the magnet, the ends are not considered in magnets of normal proportions; for this calculation we use formula (VII) which states that: the required surface is equal to the constant multiplied by the watt loss and final temperature rise. Substituting figures, let watt loss be 38.9 and final temperature rise be 210 deg.F., then we have $(200 \times 38.9) \div 210 = 37$ sq. in., the required surface. Iron clad magnet temperature calculations are essentially the same with the exception that constant 273 is substituted for 200.

Curves and Tables

TO find the required area in circular mils of the magnet wire, formula (VIII) is used. To get this area, multiply the mean length of one turn of wire in feet, that is the length of one turn in the center of the coil as indicated by E in the Electromagnet Data Table by 12 and by the ampere-turns and divide by the e.m.f.

For the sake of illustrating the working of the formula, which will be used in connection with the actual design of electromagnets we will make some assumptions. Let mean length be 1.5 ft., ampere-turns 50,000, and e.m.f. 110 volts; then the formula will read $(12 \times 1.5 \times 50{,}000) \div 110 = 8181 +$ circular mils, corresponding nearly to a No. 1 wire. The working of these formulas should be familiarized as they enter into the design of electromagnets, magnetic circuits and dynamo-electric machinery.

The diagram in the Practical Reference Tables, "Size of Wire in Circular Mils for 110-volt Direct Current Magnets" was calculated from formula (VIII) and is useful in making preliminary calculations for direct-current electromagnets. For 220 and 500-volt magnets the figure for 110-volts is multiplied by the multipliers given on the table. Let us assume the same conditions used in the working out of the last problem, then from the bottom row of figures representing ampere-turns follow upward on the vertical line from 50,000 to the intersection of the diagonal line for 1.5 ft. mean length of one turn of wire, then follow horizontally to the left-hand side of the diagram and in the column of figures representing ampere-turns read approximately 8200 c.m. We found from working out the formula that the required size is 8181 c.m. but as the diagram is used only for preliminary calculations, small refinements are not necessary.

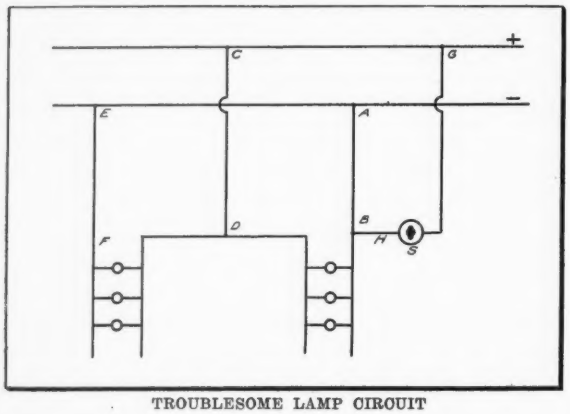
In the table, "Single Cotton Covered Magnet Wire Data" will be found data that has been much used in the calculation of electric machinery. After the size of the wire in circular mils has been determined for a specific magnet, and the ampere turns have been determined, the space occupied by the wire has to be calculated, and other characteristics determined. This table ties in with the table of "Electromagnet Data" and the 2 will be used more or less throughout this series of articles and their practical value will be seen as we make use of them in practical calculations.

ELECTRICAL CORRESPONDENCE

THAT TROUBLESOME CIRCUIT

REFERRING to the article by T. G. Thurston on page 222 of Feb. 15 issue, I think that the trouble would be removed by cutting out wire A B, but the circuit would not be correct nor would it work properly with the switch where it now is.

The 3 lamps on the left side of diagram would be burning all the time, while the lamps on the right of diagram will not burn at all, because both taps are taken off the same line.



TROUBLESOME LAMP CIRCUIT

The first thing to do is to cut off line G H.

To turn all 6 lamps on or off with a single-pole snap switch I should connect the switch on line C D. To turn the 3 lamps on or off on the right side of the diagram, connect the switch on wire A B and leave all others solid. To turn the 3 lamps on or off on the left side of diagram connect the switch on wire E F, and leave all others solid.

If Mr. Thurston will kindly look this diagram over, I feel sure he will bear out my few remarks.

H. M. Wood.

ALTERNATOR PROBLEM

A 75- kva. 60-cycle 2300-volt alternator, running at 900 r.p.m. has 8 poles. If 2 field coils or 2 poles were removed how would it affect the alternator? "A" says the voltage would be decreased, "B" says the frequency would be decreased. Which is correct? H. V. M.

A. If 2 poles were removed from an 8-pole alternator the voltage would be reduced one-fourth, and the frequency would remain the same. N. G. M.

COMMUTATOR TROUBLE

UNDER my charge I have a Commercial 250-v., 200-amp. direct-current generator with compound winding, and operating at 480 r. p. m.

It sparks but little, but in 4 places on the periphery of the commutator there are flat burned places about the width of the brushes. I have to turn the commutator down once a week and have tried undercutting the mica, and commutator compounds of all kinds to no avail. Can you suggest a remedy? O. R. W.

A. Your generator trouble may be due to one of several causes, which are hard to determine without being on the ground. At first thought it would seem that it was a winding difficulty, caused by short circuiting or open circuiting of the armature coil, which in certain types of windings on the 4-pole machines would cause burnt places on the commutator at 4 different spots.

There are, however, purely mechanical causes, such as poor contact on one point of the commutator, which throws heavier current to the other brushes of the same polarity, thereby causing them to be overloaded. This may result in burning the commutator under the brushes at the time of overloading. It would be advisable first to ascertain if all your brushes make contact with the commutator, and that there is sufficient tension on the brush-holder spring. N. G. M.

REVIVING A SMALL STORAGE BATTERY

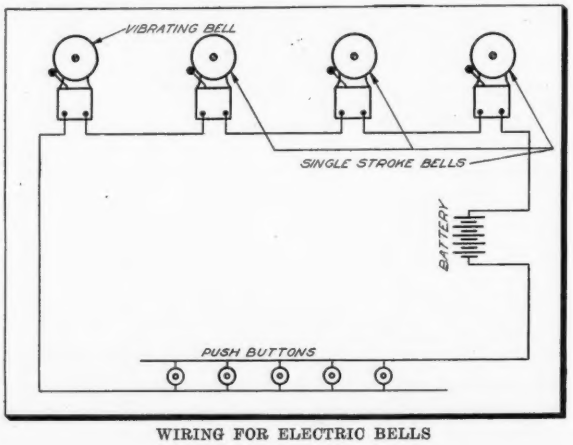
I HAVE a storage battery for gas engine ignition that does not operate enough to keep it in good condition, and it sulphates. What can I do with it?

J. P. C.

A. Charge the battery as rapidly as it is possible to send current into it without overheating. The resistance being greatly increased by the effect of the sulphate, the cell will become hot when charging. Use a thermometer to test the temperature and maintain the current at such a value that the temperature of the cell does not exceed 110 deg. F. Continue this charge until the plates begin to gas freely, then reduce the rate of charge to the normal rate and continue this until the plates again begin giving off gas. The rate of the charge should be reduced to half the normal rate and continue until further gassing again occurs. The cell should then be partly discharged and the treatment repeated. This cycle of operation may have to be carried on for some time. N. G. M.

ELECTRIC BELL WIRING

SHOULD like you to send me a sketch of the best way to wire for 5 call bells, so as to get the best results. The bells are 2 ohms resistance and I want to ring them all from one push button at one time, also to be able to use them for a return call. Expect to use 4 push buttons at first but may put on more afterwards. N. A. A.



WIRING FOR ELECTRIC BELLS

A. The accompanying sketch shows the most satisfactory way of ringing several bells at one time from one or more push buttons. Connect the bells in series as shown, using one vibrating bell and the balance single stroke bells. Under such conditions, if you wish to have a return call, it would be more satisfactory in the end to run separate circuits. N. G. M.

FOREIGN DEVELOPMENT IN THE POWER PLANT FIELD

Water Vapor and Ejector Refrigerator Machines

By J. H. Blakey

COMPRESSOR refrigerating machines are most widely used, in which the low temperature is produced by the evaporation of a liquid called the refrigerating agent in a closed compartment A (Fig. 1), called the refrigerator. This evaporation tends to lower the temperature of the refrigerator, and the bodies to be cooled are put in contact with its walls, which takes from them an amount of heat which is transmitted to the interior of the refrigerator. Ultimately there is established a steady temperature such that the amount of heat passing through the walls exactly equals that required to produce the evaporation.

Usually the refrigerator is arranged in a trough B, through which is caused to circulate by means of the pump C, a current of water or brine, according to whether it is required to have the mean temperature equal to or lower than 32 deg. F. To maintain the continuous evaporation of the liquid, it is necessary to create a partial vacuum above it. This is done by means of the compressor D, which draws off the vapor as it is disengaged. The vapor flows into the condenser E, also cooled by a current of water, producing a liquid which is cooled until its temperature is about equal to the initial temperature of the cooling water. Finally, it is drawn into the refrigerator, in which the pressure is lower than that of the condenser, by a pipe having a regulating valve F.

The refrigerating agents in common use are: ammonia, sulphurous anhydride, carbonic acid, and finally, water. Water is generally used in installations on board ship, as an escape of ammonia or sulphurous acid might make part of a ship inaccessible, or might lead to even more serious consequences.

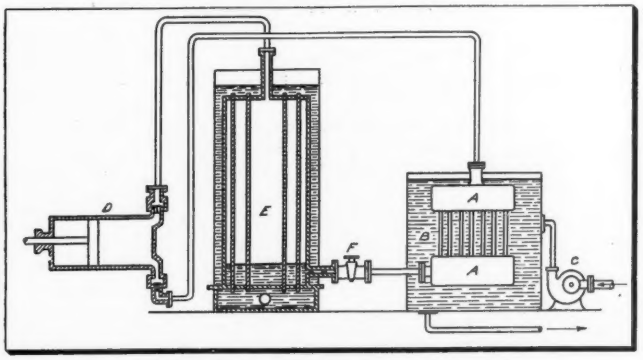


FIG. 1. COMPRESSOR REFRIGERATING MACHINE

The only difficulty in the employment of water lies in the large amount which must be kept evaporating in order to produce a considerable fall of temperature. Fortunately rotary compressors and ejectors can be arranged in which the steam moves at a great velocity, even when the dimensions of the machines are quite small.

The steam ejector is a compressor in which the fluid to be compressed is drawn by one or more jets of steam moving at great velocity, which communicates to it a part of its motion. The 2 fluids, driving and driven, pass into a throat D, Fig. 2, called the diffuser, where their energy is transformed into work of compression. The fluid to be compressed flows by a passage A into a closed chamber B, called a mixer. Steam reaches this chamber by one or several tubes c, c, c, the orifices of which are opposite the entry of the throat D, which leads to a reservoir E, in which a pressure greater than that in the chamber A is maintained.

The ejector type of refrigerating machine is considered preferable for ships, and those with a rotary compressor for installation on land.

Mons. Maurice Leblanc has for a long time studied the principle of the ejector, in order to adapt it to this new application, and has succeeded in considerably increasing its efficiency.

The wheels of a rotary compressor suitable for a water vapor refrigerating machine must have a rim velocity of about 100,000 ft. a min., and the compressor must carry 4 wheels on the same shaft. For an apparatus of medium power a speed of 30,000 r.p.m. is necessary.

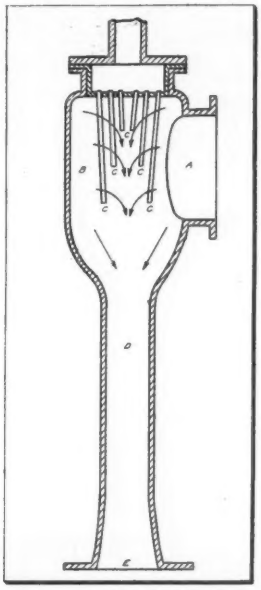


FIG. 2. VAPOR EJECTOR

In order to resist centrifugal force, the rims of the compressor wheels are made, not of steel, but of vegetable fibers laid parallel one with the other, and glued together with dissolved cellulose.

To insure the equilibrium of the rotor, it has been necessary to construct automatic equilibrators which with rotation tend constantly to draw one of the principal axes of the rotor, passing through its center of gravity, into coincidence with its geometric axes. But the working of these equilibrators made it necessary that the shaft of the rotor be free at each moment to choose its own axis of rotation. The shaft had then a tendency to roll on the fixed rings which surround it. This has been prevented by the employment of special guard rings which limit its displacement.—Translated from La Science au Siecle, Jan. 1912.

TESTS ON SPIRO TURBINES

Using Fan in Free Air as a Dynamometer

By Herbert Coward

THE Buffalo Forge Co. arranged with the writer to undertake this series of tests which are now in progress and partial results of which are published in the following. It is the intention to follow the zero back pressure tests with others at various vacua, and it may be mentioned that preliminary tests indicate very interesting economies.

To apply load to these turbines of various sizes in order to secure curves covering a wide range of speed and pressure variables, it was necessary to devise a proper dynamometer. This was done in a simple way by selecting a number of sizes of blast wheels with diameters ranging from 8 in. to 4 ft., especially rugged in construction to stand up under heavy absorption.

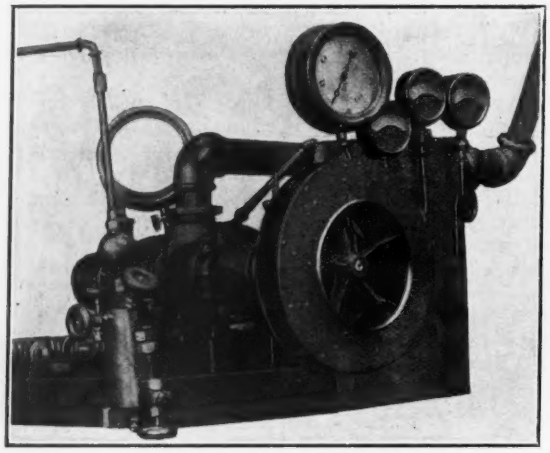


FIG. 1. TURBINE AS FITTED FOR TEST

In calibrating these "fan dynamometers," as we call them, several interesting facts were observed. It may not be known to the majority of readers that a blast wheel run open in the air, as we run these dynamometers, requires from 200 to 260 per cent more power at a given speed than when in housing under working conditions. The fact that the load builds up so rapidly in free air and that it is absolutely constant at a given speed, barometric pressure, temperature and humidity, makes the blast wheel dynamometer ideal for speeds between 1000 to 5000 r.p.m. The correction for barometric pressure, humidity and temperature are direct corrections, involving no guess work or estimating.

The blast wheel was calibrated on a variable speed test motor, armature current being read, and the result corrected for no load current and heat loss for each load and speed condition, the resulting figures being the net total watts input into the wheel necessary to attain each speed.

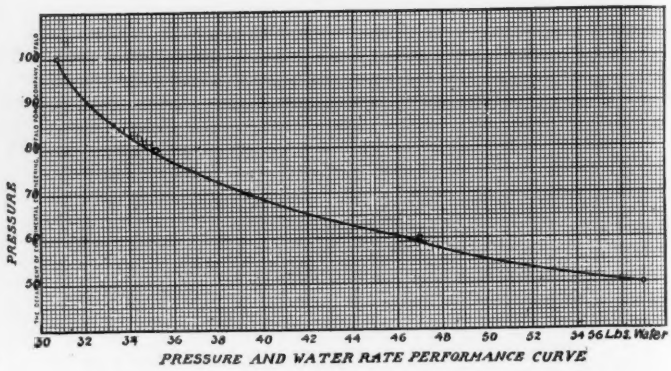


FIG. 3. VARIATION OF WATER RATE WITH INITIAL PRESSURE FOR 100-HP. TURBINE AT ZERO BACK PRESSURE

From these results curves were plotted for each wheel with horsepower as ordinates and r.p.m. as abscissas.

The arrangement for test is shown in Fig. 1. Steam is first put through a separator and then, after passing a calorimeter, enters the turbine. From the exhaust, it is led to a surface condenser arranged with air vent to break the vacuum and give atmospheric conditions which were further determined by a U tube manometer capable of indicating the slightest amount of pressure or vacuum.

The condensate was allowed to flow out of the condenser into a tank mounted on scales.

Over 100 different tests were made on each size turbine at varying load, speed, and steam pressure.

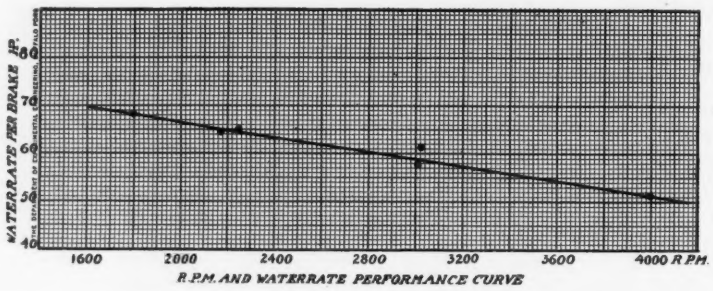


FIG. 2. VARIATION OF WATER RATE WITH SPEED FOR 6-HP. TURBINE AT 100 LB. INITIAL, ZERO BACK PRESSURE

The results of the tests for a 6-hp. turbine at 100 lb. pressure are shown in Fig. 3, the variation of water-rate with r.p.m. and hp. It is interesting to note that the absence of reverse indicates that conditions of maximum economy have not as yet been reached.

Figure 2 shows by the curve how the steam consumption decreases with increase of speed. As this curve still has a downward direction at the highest speed it indicates that the point of maximum economy was not reached within the limits of this test.

Figure 3 is for the 100-hp. turbine and shows the variation of water rate with pressure.

FUNDAMENTALS OF THE CHAIN GRATE STOKER

Abstract of Discussion Before the Detroit Engineering Society

By Joseph Harrington*

MR. HARRINGTON showed the basic principles of the chain grate, illustrating his talk by a number of lantern slides, showing the typical fuel bed of the chain grate stoker, several cuts of the stoker itself, and a number of typical installation drawings, calling particular attention to the large combustion chamber which the Green Engineering Co. is now advocating as essential to furnace efficiency, which has become recognized as the most important part of combined efficiency of a stoker installation.

Fuel Feeding

THE chain grate exemplifies certain principles in the automatic stoking of coal; the fuel is fed to the stoker with mechanical regularity and uniformity, the amount of coal per unit of time and per unit of grate surface being exactly the same so long as the adjustments of the stoker are not altered, gravity action being entirely eliminated. This condition provides at the same time for the uniform ignition of the fuel throughout the entire width of the entering fuel bed, and the resulting steps in the progressive combustion of the coal are thereby successfully initiated, so that the volatile constituents of the fuel are distilled off in a perfectly uniform and regular manner.

No extraordinary preparations must be made to accommodate sudden bursts of volatile liberated from undue and unusual amounts of fuel suddenly entering the furnace. Smokelessness, therefore, most easily results, and the uniformity of the ignition of the coal is followed by uniformity in the oxidation of the thickest carbon, resulting in even furnace temperature and continuous output from the boiler.

The substantially horizonal condition of the grate surface results in uniformity of fuel thickness throughout the entire range of operation, so that hand assistance to the flow of coal into the furnace is unnecessary, nor are bars, hooks, or rakes used in maintaining uniform fuel bed conditions during the later stages of combustion.

Progressive Burning

THE next principle in the chain grate method of stoking is the undisturbed condition of the fuel bed throughout the entire combustion process. As the green coal enters the front of the furnace, ignition takes place, and the fuel burns against the direction of the flow of the entering air towards the grate surface. As the fuel is carried forward, combustion penetrates to the grate surface, and then proceeds with the greatest rapidity to the underside of the layer, where the fuel gets the full benefit of the oxidation in the air. Resulting from this inherent condition, complete oxidation occurs first at the grate surface, and the ash layer begins to form near the rear of the furnace, directly on the grate surface, gradually increasing in thickness as the layer of carbon above diminishes. The most important benefits of the chain grate method of stoking are directly attributable to this natural condition.

Inversion of the fuel bed, resulting in bringing the ash to the surface immediately, results in the fusing of such ash into clinkers of greater or less dimensions. If the inversion is but slight, clinkers of moderate size are formed; but if the inverting process is continuous and ash is repeatedly brought to the surface of the incandescent fuel bed, clinkers of immoderate size are necessarily formed.

There is no possible way of avoiding clinker formation in any furnace not enjoying the benefits of undisturbed progressive combustion. Care in selecting fuels having ash of a high fusing point, will reduce this trouble, if moderate furnace temperatures are maintained. The impracticability of this, however, is well known, and the modern demand for high ratings precludes the possibility of continuously operating stoker furnaces at low temperatures.

In the chain grate, however, the resultant ash layer is only that resulting from the combustion of a 6, 8, or 10-in. layer of coal, and under no circumstances can it be of such thickness that continuous removal from the furnace cannot be provided for. Coals having ⅓ ash are in daily use with these stokers, and entire power plants run the year round with no better fuel at any time.

Clearing Out Refuse

MOST conspicuous of all the characteristics of the chain grate, and making it completely automatic, is the continuous and automatic discharge of the refuse, without dumping devices or clinker crushers. The discharge, being automatic, does not depend upon the attention of the operator, and no unburned fuel is precipitated into the pit.

Feed of the fuel in the chain grate results in a peculiar condition most favorable for the smokeless combustion of soft coal. It is a part of the general scheme that the coal enters the furnace at a point which is most distant from the heating surface on the boiler, and the volatile gases distilled in greatest volume at this point have in consequence the farthest travel and the greatest time in the furnace.

Burning Coking Coals

IT is not generally known that the Green Engineering Co. is manufacturing a stoker of the chain grate type, on which the eastern or coking coals can be successfully burned. These coals tend to form a continuous cake upon subjection to the heat of the furnace. If left undisturbed, this cake forms an impervious layer, covering the entire grate surface, and combustion is extinguished from sheer lack of oxygen.

The speaker, however, developed the fact that a slight continuous agitation during the period when the volatile combustible matter was being driven off, prevented the formation of the continuous cake and resulted in a fragmentary condition of the resultant coke, which was porous in character and would burn out on the chain grate surface to a clean and uniform ash.

*Of the Green Engineering Co.

This is the governing principle of the "L" type stoker, which was devised and patented by the speaker.

By mechanical means, the stoker itself feeds the coal from the hopper on to the top of the coking incline, which consists of 2 plates extending the width of the furnace, and adjustable as to inclination; the lower one is mechanically caused to vibrate through a few degrees. Disturbance of the fuel bed, due to the mechanical agitation provided by this incline, is sufficient to accomplish the disintegrating effect which is required with these coals.

On account of the porous condition of the fuel bed, thick fires can be carried and high efficiencies obtained. Continuous gas analyses of 16 per cent of CO_2 are the rule, and this can be carried to a greater extent, if desired.

The air cooled member, also devised by the speaker, for the purpose of retaining all unconsumed matter in the furnace, serves to protect the discharge of the refuse so that nothing but completely burned out ash can be dumped. The combination of thick uniform fuel beds, and the prevention of any waste in the ash pit makes possible furnace efficiencies as high as 95 per cent; in other words, the losses chargeable to the stoker proper can be reduced to about 5 per cent. This feature is best distinguished by the term "furnace efficiency," as distinguished from either the combined efficiency or boiler efficiency.

The chain grate thus becomes of almost universal adaptability and the development of a furnace suitable for burning high moisture and high ash coals, together with that just described for eastern coals, permits the Green chain grate stoker to enter any field where any coal other than true anthracite is in use.

ELECTRICALLY DRIVEN REFRIGERATING MACHINERY

Application of Electric Drive to the Various Systems of Ice Making and Refrigeration

IN general there are 2 methods employed in the manufacture of artificial ice, the first known as the can system which requires distilled water to produce a clear ice free from bubbles, and second the plate system in which clear ice is manufactured from the raw or undistilled water, usually in large plates. Both of these systems require compressors to supply the necessary liquid gas for freezing.

In addition to the actual manufacture of ice, numerous refrigerating plants are operated from electric motors, the liquid ammonia or other gas being utilized for cooling a brine which is circulated through the compartments or coils which it is desired to cool.

While the direct current motor is somewhat more efficient when operated at variable speed, the alternating current induction motor is most commonly used since it is adapted to operation from standard alternating current circuits of central stations. The desired flexibility may easily be obtained by the installation of two or more units so proportioned that they can be operated singly or together at approximately full load and normal speed.

Plate System Plant

DEVELOPMENT of the artificial ice industry has received considerable impetus in the Niagara Falls district from the advent of cheap hydro-electric power. The plant of the Crystal Ice and Storage Company of Buffalo is only one of many similar enterprises which are being successfully operated from this exceptionally reliable power.

This company employs the plate system using ordinary spring water and the equipment is therefore particularly suited to electrical operation since the need for steam boilers or even evaporators is entirely eliminated.

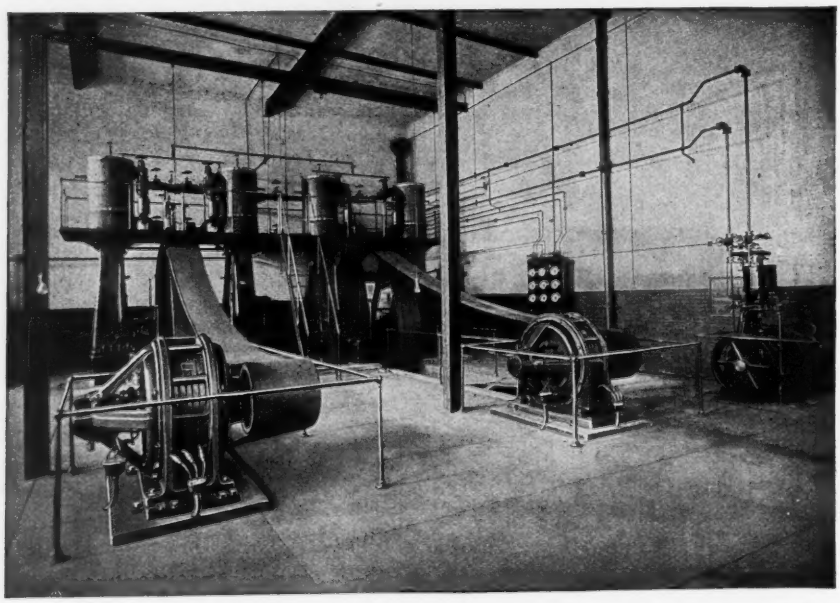


FIG. 1. TWO 90-TON COMPRESSORS DRIVEN BY 175-HP. VARIABLE SPEED INDUCTION MOTORS

In the plate system the ice is formed and built up on an artificially cooled plate used in connection with an ammonia compressor. The liquid ammonia is allowed to evaporate in a system of coils placed between the vertical steel plates, which in this case are 15½ ft. long by 9½ ft. wide. A cake of ice of these dimensions and 12 in. thick weighs about 9400 lb. There are 16 tanks in use, each containing plates for 8 of these cakes. Electric drive is used for all machinery.

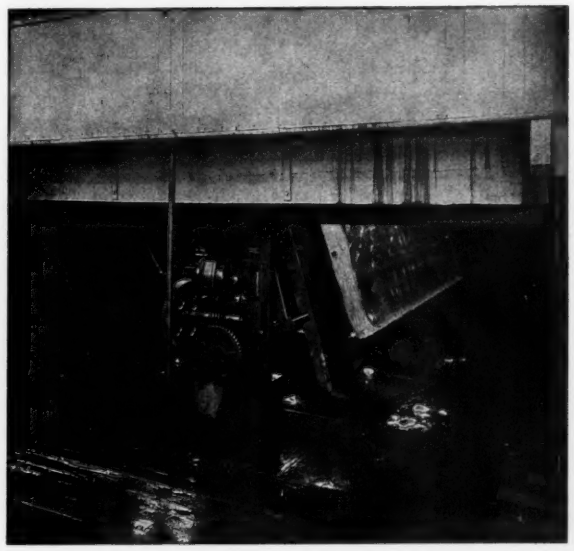


FIG 2. TWO-HP. INDUCTION MOTOR OPERATING TILTING TABLE

A 200-hp. 2200-volt General Electric induction motor furnishes power to the ammonia compressor which is rope-driven from a large pulley located between the 2 horizontal cylinders. This equipment is rated at 100 tons of ice a day and it is possible to disconnect one side of the compressor, operating the other side as a single engine, thus increasing the flexibility of the plant. In order further to vary the rate of compression, the motor is equipped with a wound rotor and slip rings, the external resistance for regulating the speed being inserted by means of a drum controller. A speed reduction to one-half normal is thus made possible.

The average daily production is about 50 tons, but during hot weather the output sometimes runs as high as 100 tons a day.

In order to produce ice free from air bubbles the water is kept in motion while freezing by the use of compressed air. When the cake is built up to the desired thickness a hot ammonia gas is sent through the pipe system, loosening the cake ready for harvesting.

The tanks are arranged in 2 rows, each served by a 7-ton crane. To facilitate handling, 2 eyebolts are cast into each cake of ice. Each crane is operated by 2 induction motors of 5 and 3 hp., respectively, which are of the slip ring type and are therefore suitable for starting under load.

After the cake is placed on the tilting table the supporting bolts must be removed preparatory to sawing. This is accomplished without difficulty by using a heavy current of electricity to loosen the rods. The projecting terminals at the lower end of the bolts are connected together by means of a flexible copper cable and voltage is applied to the upper ends. A specially wound transformer is used for the purpose, rated 1 kw. at 4 volts on the secondary side. The 250-ampere current thus obtained will loosen the bolts in about one minute.

The ice cakes are lowered to a horizontal position by means of 2 tilting tables, one of which is shown in Fig. 2. The operating motor for this table is rated 2 hp. at 750 r.p.m. and is wired for reverse operation to allow a range of motion through nearly 180 deg. This movement places the cake flat side down on the table regardless of its position when removed from the tank.

The ice is now ready for the motor-driven saw. This saw is mounted on a revolving stand and traveller, so arranged that a cut may be made in either of 2 directions. The motor speed is 1500 r.p.m. at its normal rating of 3 hp. and the saw runs about 1200 r.p.m. The saving in labor over the harvesting of natural ice is evident from the fact that the entire output is handled by 2 men, from the freezing tanks to the loading platform.

In addition to those mentioned above several small induction motors are used ranging in size from 2 to 7½ hp. These motors are supplied from the 2200-volt circuit through transformers stepping down to 220 volts and are used for the operation of water and brine pumps, compressors and ice elevator.

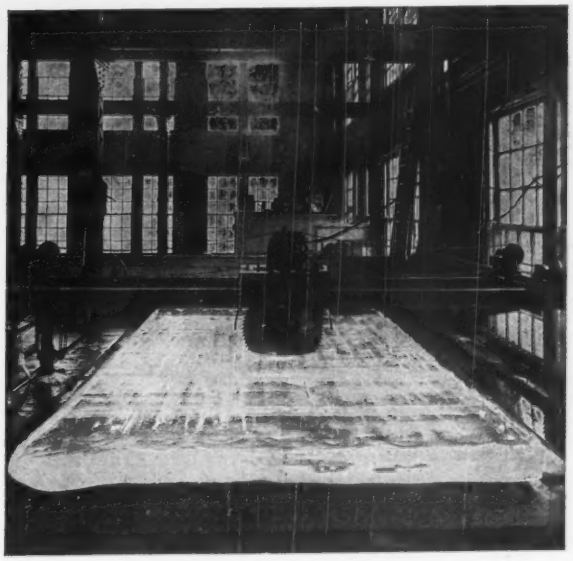


FIG. 3. THREE-HP. INDUCTION MOTOR DRIVING ICE SAW

Can System Plant

IN order to manufacture ice at a reasonable profit by the can system it is necessary either to obtain the distilled water as a byproduct from steamdriven machinery or to install special distilling apparatus which will evaporate a considerably larger amount of water per pound of coal than is obtained by the ordinary boiler equipment. The boiler room equipment of the Webster-Citizens Ice Co. of Buffalo consists of 2 85-hp. horizontal tubular boilers fitted with mechanical stokers, and supplementary distilling apparatus. This outfit supplies distilled water for pro-

ducing approximately 100 tons of ice a day. The total output of this plant for 1910 was in excess of 30,000 tons, with a maximum daily output of about 125 tons. The energy required by electric motors varied from 50 to 65 hp.-hours per ton.

The engine room contains 2 vertical 100-ton ammonia compressors each belted to a 175-hp. variable speed induction motor. Energy is supplied by the local central company at 25 cycles and 2200 volts. Speed control is effected by the insertion of an external resistance into the rotor circuit by means of a drum controller. This arrangement allows the motors to be operated continuously at 13 different speeds varying the compressor speed from 72 r.p.m. to 11

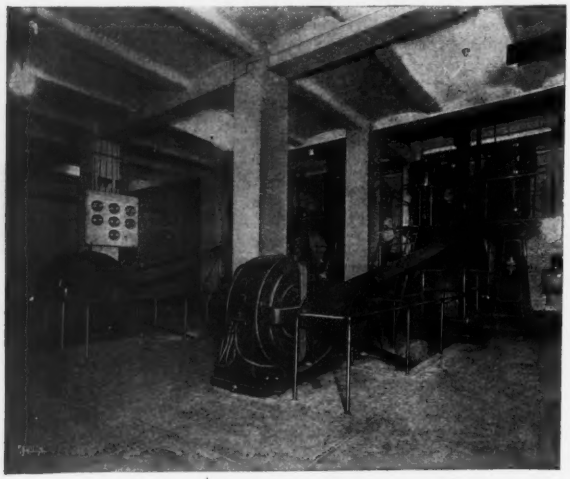


FIG. 4. ONE 90-HP. AND ONE 125-HP. DIRECT CURRENT MOTORS DRIVING AMMONIA COMPRESSORS

r.p.m. A flexibility of speed control is thus provided which is practically equivalent to that of a steam-operated compressor. During the winter months one compressor unit is sufficient to supply all of the ice required.

In addition to the ice machines this plant also employs several small motors driving 4 brine agitators, several pumps, 2 cranes and other machinery. These motors are operated at 440 volts through 2 20-kw. 2200/440 volt transformers.

Refrigerating Plant

ELECTRICAL equipment of the J. M. Horton Co.'s new factory is a good example of the economies possible in the isolated plant operation of refrigerating machines, and especially of the flexibility, cleanliness and reliability of operation accompanying electric drive in a plant of this character. This company employs producer gas engines direct connected to continuous current generators, which in turn drive the adjustable speed motors belted to the refrigerating machines. The required flexibility is thus obtained by using electricity as a medium of power transmission, with motors for driving the several machines and supplementary equipment.

Reliability of operation is especially important, since the connection to the 3-wire mains of the local power company has only sufficient capacity for lighting the building. This connection is used regularly for night lighting when the generating units are shut down, and also insures lights in case of accident.

Gas Engines

THE 2 generator sets consist of 3-cylinder Rathbun-Jones gas engines of the vertical type, direct connected to 150-kw. General Electric generators, operated from producer gas generated on the floor above. Ignition is obtained from a battery of storage cells charged from a small motor-generator set.

The generators are standard engine type direct-current machines, each with a normal rating of 150 kw. at 250 volts and 257 r.p.m. Single-phase slip rings are provided for the derivation of a neutral wire, which is obtained through a compensator rated for 25 per cent unbalancing. This connection supplies current at 125 volts for the incandescent lighting system, while all of the motors operate at full generator voltage.

The present equipment comprises 2 vertical compressors one of which is belt connected to a 90-hp. motor and rated at 50 tons refrigeration; the other to a 125-hp. motor and rated at 75 tons refrigeration. The motors are equipped with commutating poles and are designed for a speed variation ranging from 250 r.p.m. to 500 r.p.m.; the change in speed being effected by field control. At the higher speed the compressors deliver full rated output at 65 r.p.m. Free ammonia gas is first compressed by the refrigerating machine to a pressure of about 150 lb. per square inch. This operation increases the temperature of the gas and necessitates the employment of cooling coils, by means of which the temperature is again reduced to the condensing point. The liquid ammonia thus obtained is allowed to evaporate under reduced pressure in a coil of pipe placed in a tank containing brine for the circulating system.

Pumps are required for circulating the cold brine and these are also motordriven. An adjustable speed 35-hp. motor direct connected to an 800-gal. turbine pump, supplies brine for cooling one of the large chill rooms, in which the ice cream is set to harden after leaving the freezers. This pump takes the brine from the cooling tank and forces it through the coils in the large chill room on the second floor, while a 400-gal. pump supplies brine to the mixers, freezers and the third floor chill room.

"THAT MAN OVER there with the white hair gave me the greatest gift I ever received," said one successful business man to another. "It wasn't money," he continued in answer to his companion's look of interrogation, "it wasn't any material substance. When I was a youngster, struggling to get ahead, he listened to me as I told him my dreams and told me that he believed in me and in my ability to make good. He also said that he would keep watch because he wanted to see me grow as he knew I would grow. He probably forgot all about it years ago. But the effect of his speech was such that I have never forgotten how I felt when he said: 'I believe in you,' and I've never been able to shake off the feeling that he has always watched me. He has in that way done more than any other man to help me win the success that is mine. That is why I say he gave me the greatest gift I ever received."—Electrician and Mechanic.

SPEAKING OF THE use of graphite in boilers, Asa P. Hyde of Binghamton, N. Y., states that when fed through the feed pump and hot water meter in connection with compound, it has lessened the wear and need for frequent recalibration of the meter, the pump runs easier and the packing wears longer.

THE SLIDE RULE AND THE PUMP

To Check the Pump Capacity; to Figure the Duty and Cost Per One-Thousand Gallons, and How to Bunch Calculations So As to Make the Rule Do the Most Work with the least Trouble

By H. L. Sherman

PUMPING of water is one of the simplest, yet commonest problems with which the engineer has to deal, and the slide rule comes in as an important help.

Take for example a duplex, low-duty, triple-expansion condensing pump, having a surface condenser, the plunger 13½ in. diameter, the high-pressure steam cylinder 14 in., intermediate 28 in., and low-pressure 36⅜ in., with stroke 24 in. The builder's rating on this pump is 2,000,000 gal. in 24 hours, running at 100 strokes per minute.

First let us figure how much water this must pump to the stroke to fulfill its rating. The number of gallons for one stroke will be the total gallons in 24 hours, divided by the strokes in 24 hours, or 2,000,000 divided by (24×60×100), which equals 13.86 gal. per stroke. To get the best results on the slide rule write this as one series of operations, expressed in a single expression, thus:

$$\frac{2{,}000{,}000}{24 \times 60 \times 100} = 13.86$$

To perform this operation, place 24 on C over 2 on D, the lower scale; then move the runner over 1 on C, and 6 on the slide to the runner, and under 1 on the slide read 1386 on D, which is the answer in gallons. Now, has the pump maker given us all we have bargained for?

Water Per Stroke

IN order to determine this we must figure the actual plunger displacement. As this pump is of the usual low duty type, cushion valves are used to regulate the stroke and sufficient clearance must be kept to prevent the piston from striking the head under all conditions. If we allow ⅜ in. at each end it will give ¾ in. for both ends and will leave as the greatest stroke available in a 24-in. cylinder the working length of 23¼ in. The plunger rod is 2½ in. diameter, and, as the space occupied by this rod cannot be filled with water we will deduct half the cubic contents of the rod or 23¼ in. for 2½ in. rod, from the plunger displacement, since the rod is on only one end of the plunger and so affects only one-half of the strokes.

The calculation will be: area of the rod times half the stroke, or:

$$\frac{4.9 \times 23.25}{2} = 57.$$

and the slide rule operations are as follows: Place 2 on scale C over 4.9 on scale D, and bring the runner to 2325 on C. Under the runner on D find 57 cu. in.

Areas of circles are best taken from the reference tables, but if such tables are not handy, the area is 0.7854×2.5^2. Set the runner to 25 on D which sets it to 25 squared on A; bring the center 1 on scale B to the runner and over 7854 on B, which is shown by a special mark on the righthand end, find 49 on A.

For the plunger displacement, the calculation is made much the same way as the former one, or is area times length less 57 cu. in. or one-half of the rod. The operation can be expressed by $143.1 \times 23.25 = 3330$; and this minus 57 equals 3273 cu. in. Then to reduce this to U. S. gallons divide by 231 equals 14.16 gal. as near as can be read on the rule. The operations are all simple and need not be stated in detail.

Now as the pump maker has figured on 13.86 gal. per stroke of the pump, he has allowed $13.86 \div 14.16 = 0.979$ or 97.9 per cent of the total plunger displacement, or the slip is taken as 2.1 per cent. This would be allowing 0.3 gal. per stroke for slippage which seems to the writer too small, but this may vary from time to time, depending on the packing, valves, springs and perhaps some other details.

Rod, 2½ in. diameter
Plunger, 13½ in. diameter
High Pressure, 14 in. diameter
Intermediate, 28 in. "
Low Pressure, 36⅜ in "
Stroke, 24 in.
Strokes per min., 100
" in 12 hr., 76,200
Coal in 12 hr., 8100 lb.

(A) $\frac{2{,}000{,}000}{24 \times 60 \times 100} = 13.86$ gal. per stroke

(B) Rod Volume $= \frac{2.5^2 \times 0.7854 \times 23.25}{2} = 57$ cu. in.

(C) Plunger Volume $= 13.5^2 \times 0.7854 \times 23.25 = 3330$ cu. in.
$3330 - 57 = 3273$ cu. in.

(D) $\frac{3273}{231} = 14.16$ gal. per stroke

(E) $\frac{13.86}{14.16} = 0.979$ or 97.9%; 100 − 97.9 = 2.1% slip
14.16 − 13.86 = 0.3 gal. slip

(F) $\frac{76{,}200}{12 \times 60} = 106$ strokes per min

(G) $\frac{8100 \times 2.40}{2000} = \$9.72$ coal cost

(H) $\frac{9.72 \times 1000}{76{,}200 \times 13.86} = \$0.092$ per 1000 gal.
78,620 − 70,550 = 8070 gal. feed water

(I) $8070 \times 8.33 = 67{,}200$ lb. feed water

(J) $\frac{67{,}200}{8100} = 8.3$ lb. water per lb. coal

(K) $8.3 \times 1.071 = 8.9$ lb. water from and at 212 deg. F.

(L) $\frac{8100 \times 240 \times 1000}{2000 \times 76{,}200 \times 13.86} = \$0.092$

(M) $\frac{8070 \times 8.33 \times 1.071}{8100} = 8.9$ lb.

CONVENIENT ARRANGEMENT OF OPERATIONS FOR SLIDE RULE FIGURING

Meter manufacturers will tell us that the proper way to find out how much water we are pumping is to measure it with a water meter. But, inasmuch as the most accurate water meter which can be furnished, would be a displacement meter, I fail to see how, as a practical thing, a stroke register does not give nearly as good results when we know the quantity of water which is pumped each stroke.

Figuring Coal Cost

NOW to consider the cost of pumping. Suppose that the stroke register shows in a 12-hr. run 76,200 strokes which will be nearly 106 strokes a minute; $76{,}200 \div (12 \times 60) = 106$. If we weigh our coal and meter our feed water, we get say 8100 lb. of coal burned in 12 hr. costing $2.40 a ton of 2000 lb. in the boiler house. Then the coal will be:

$$\frac{8100 \times 2.40}{2000} = \$9.72.$$

And the cost per thousand gallons pumped will be:

$$\frac{9.72 \times 1000}{76{,}200 \times 13.86} = \$0.092,$$

as nearly as we can read the rule. The operations are, divide 972 by 762; multiply by 1; divide by 1386 and read the answer under the index on C.

Now the amount of water pumped is $76{,}200 \times 13.86 = 1{,}074{,}000$ gal.

Reading our feed-water meter we find the final reading 78,620 gal. and the initial reading 70,550, so that the water used is the difference or $78{,}620 - 70{,}550 =$ 8070 gal.; allowing 8⅓ lb. per gallon, gives $8070 \times 8.33 = 67{,}200$ lb., of feed water evaporated by the boiler. Then the actual amount of water actually evaporated per pound of coal burned will be $67{,}200 \div 8100 = 8.3$ lb.

If we have an efficient oil and grease extractor, we can use the warm water from our condenser in the boilers and at a vacuum of 26 in. we will get water at about 125 deg. F. If the only steam available to heat this is that from the boiler feed pump we should be able to get this up to about 160 deg. F. when it enters the boiler and by passing it through a home-made economizer, which will put it up to about 185 deg. F., we get another gain. Carrying an average boiler pressure of about 115 lb. gage, the factor of evaporation with the temperature at 185 deg. is 1.071 as found from the Practical Reference Tables of a former issue. Thus the evaporation from and at 112 deg. equivalent to the actual evaporation by the boiler is $8.3 \times 1.071 = 8.9$ lb. of water which is evaporated per pound of coal.

Best Use of Slide Rule

COMING now to a consideration of how the slide rule may be used to the best advantage to save time, consider the example as shown in the figure. First collect all the data which are to be used in the problem at the head of the sheet for ready reference. Then arrange the first series of operations as an expression of continued multiplication and division; start with the first operation of division, dividing 2 by 24, then divide by 60 and then by 100. In this way the smallest number of operations on the rule will be made necessary. These have already been indicated.

The next operation is computing the volume ot the rod and the series of operations are as shown in the expression B. Here, since one figure is to be squared we must use the A and B scales, as already explained, and we start by placing the runner at 25 on the D scale in order to get 25^2 on the A scale. Then bring 2 on the B scale to the runner in order to give division, carry the runner to 7854, then 1 to the runner and the runner to 2325 in the regular way, and read the result on the A scale. The operation shown in expression C, for the plunger volume is the same, except that there is no division. The operations of subtraction and addition must, of course, be performed on the paper as the slide rule does not do these accurately. Operations shown in expressions D and E are simple division; that in F is simple continued division.

Taking up the operation shown in expressions G and H. We note that the result of expression G is used in expression H. We therefore combine the operations of these two expressions as shown in expression L. As before, we start with the first division, dividing 81 by 2, then multiply by 240, then divide by 762, then multiply by 1 and divide by 1386, taking alternately a multiplication and a division so as to reduce the number of motions of slide and runner. The final answer desired, the cost per 1000 gal. pumped, is found in one series of operations.

In like manner the operations of expressions I, J and K may be combined into a single operation as shown at M. The result of the multiplication I is used in the division J, and the result of this division in the multiplication at K, or combined, we get M, and as before, we first divide 807 by 81, then multiply by 833, and then by 1071, giving the final result directly without bothering with the intermediate values. It is, of course, possible to take off any intermediate value at any time by simply reading the slide rule and setting down the desired quantity, but combining as many operations as possible in a single expression before using the slide rule saves a number of settings of slide and runner and also reduces the likelihood of errors in making the settings.

In cases where it is not easy to see how the result of one operation will enter into another operation, the work can be reduced by performing, say, first, the operations shown in expression G, then leaving the rule lying with the setting as found there until the desired operations of expression H are set down, and then going on from the rule as previously set to the new series of operations. In this way considerable saving of time is effected, but care must, of course, be taken to see that the setting of slide and runner are not changed while the rule is out of use.

MUSCULAR AND HORSEPOWER

GLIBLY as everyone now talks of horsepower there are few things concerning which the average man knows so very little as he does of what strength the human or the animal is capable of exerting. Some idea of this has come to light through a series of interesting tests recently made to determine the respective pulling power of horses, men and elephants. Two horses weighing 1600 lb. each, together pulled 3750 lb. or 550 lb. more than their combined weight. One elephant weighing 12,000 pulled 8750 or 3250 lb. less than its weight. Fifty men, aggregating 7500 lb. in weight, pulled 8750 lb., or just as much as the single elephant; but, like the horses, they pulled more than their own weight. One hundred men pulled 12,000 lb.—Penberthy Engineer and Fireman.

IN A RECENTLY developed injector made by Koerting Bros., of Germany, the feed is taken from a pressure tank, the pressure being produced by a special nozzle of the injector. The tank is periodically filled by gravity, the pressure being meanwhile relieved. Forcing into the boiler is done by a nozzle as usual. This injector will take water at 212 deg. F., and deliver to the boiler at 266 deg. F.

REPORTS STATE that the price paid by the British Navy for fuel oil for use in their Diesel engines is 4½ cents a gallon.

LETTERS DIRECT FROM THE PLANT

Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

BROKEN FLYWHEEL

THE sketch shows the 16-ft. flywheel of a 20 by 42-in. Putnam engine built for 65 r.p.m., which was broken as shown, caused by accidentally dropping while being installed. I do not know what other method was used to fasten this broken piece on, other than shrinking the piece in as shown, as apparently there was nothing else used.

This wheel has been running 10 hr. every working day for 40 yr., as near as I am able to get information, 5 of which I had charge myself. It has worn out 2 sets of boilers and some 4 yr. ago was taken away to be installed somewhere in the middle states to start on another era. While running in Lynn, Mass., it ran at 65 r.p.m., giving a rim speed of 3267 ft. a min.,

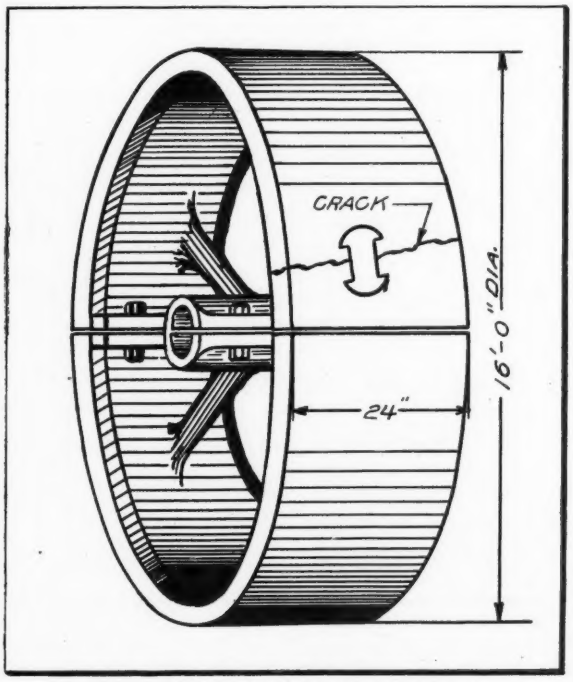


FIG. 1. REPAIR OF BROKEN FLYWHEEL

which is a trifle more than ½ as fast as a wheel in perfect condition would be allowed to run, which is 6000 ft. a min., yet it never gave any trouble. At the time this engine was installed it was to be made better than the other engines, as $500.00 extra was to be given for extra finish, and then to have allowed the flywheel to drop and break was a sad ending.

On taking charge of this engine I examined the inside of the cylinder and found that on the lefthand side the bore was worn off ⅛ in. lower than the counterbore so that the cylinder was larger than the counterbore on the left side.

This engine had its piston rod fastened to the crosshead by a key and I had much trouble in keeping this pin down. Upon examination I found the key leaned edgeways, which means that the engine had gotten water sometime between the piston and crank end head, while at the same time it probably stripped the governor gears, which are run by geared cam shaft, as I found several gears broken.

Every time this engine took steam on the head end, the center of the cylinder head would spring out

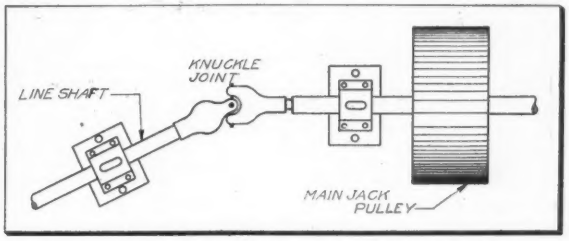


FIG. 2. KNUCKLE JOINT IN MAIN LINE SHAFT

3/32 in. and I think the cylinder head would weigh 175 lb., as I have put it on many times. The jack shaft was run with a knuckle joint because the engine was set out of line with the main line shaft. This knuckle joint carried the main shaft which was 325 ft. long and gave power to 6 factories at one time and for 40 yr. carrying the load ranging from 150 to 200.

A. C. Waldron.

OIL BURNING FURNACE

I NOTICE in Practical Engineer, page 943, Sept. 15, 1912, C. S. Robinson asks for criticisms on the construction of combustion chambers for gas fuel. Being familiar with oil burning for the last 12 yr., I will state the oil will do the same for a boiler sheet (and very quickly) as the illustrations shown.

The way we build our furnaces here in the West is different from the sketch he showed. We build the floor of the combustion chamber level from the back of the grate bars to end of the boiler and up to within about 24 in. of the bottom of the boiler and plaster it over well with cement and sand, mixed about 1 part cement and 2 parts sand, then we put in the grate bars, or if there are none used brick up the space in the ash pit; then we put the burner in the front above the grate bars, as nearly central as it can be conveniently, but the tip or point of the burner points down, so if the flame strikes anything it will strike the floor of the combustion chamber behind the grate bars and not strike the boiler sheet. Of course it is the object to have the flame lie as close up to the bottom, or hug the boiler, as possible.

If we have grates, which nearly all boilers of that type have, for burning other kinds of fuel, we brick up on both sides of the grates, leaving a space directly

under the burner; this can be regulated according to the amount of stack draft there is; by having your burner in the ash pit there is a chance for too much cold air to come in to retard the fire.

I have remodeled a great many furnaces and have found this to give the best results and I cannot see why the same kind of a furnace will not work with good results on gas. H. A. C.

TROUBLE WITH FEED-WATER HEATER

RECENTLY in a plant near ours they experienced trouble with their Berryman feed-water heater. It heated the feed water as much as it ever did—180 to 197 deg. F.—but the heater would not give over

FIG. 1. HEATER TUBES AS THEY APPEARED WHEN TAKEN FROM SHELL

enough of the exhaust steam to heat the drying room, as it had been doing for several years. They have a Corliss engine which exhausts through the heater, and between the heater and engine there are 2 connections of pipe lines, each of which conveys steam from the exhaust line to 2 separate drying rooms. We

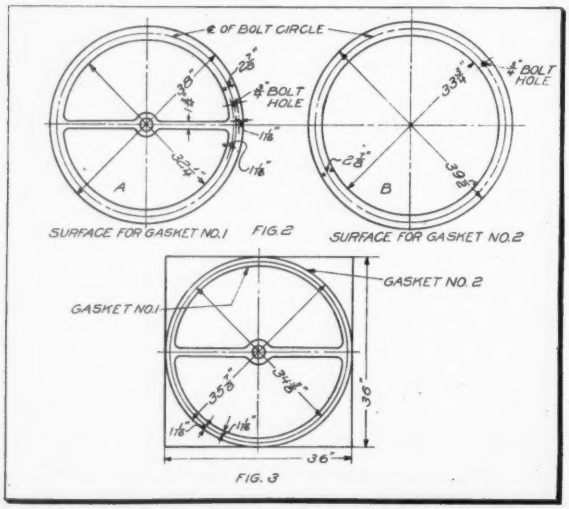


FIG. 2. DIMENSIONS OF SURFACES TO BE PACKED
FIG. 3. DIMENSIONS OF GASKET USED

closed the stop valves on these 2 latter lines and got enough back-pressure on the engine to make it take steam full stroke about half the time. Although the design of the heater and its connections were such as easily to take care of all the exhaust with a back-pressure of not more than 20 lb. absolute. So it was decided to take the coils out and examine them; and the picture, Fig. 1, shows the condition; 98½ lb. of mud and scale were deposited on the surfaces of the tubes and tube sheet of the inlet side. Some of the tubes were entirely closed up with this accumulation; others had holes about the diameter of a lead pencil remaining. How this heater got the feed water to a temperature of even 180 deg. F., I don't see.

In the course of looking over and discussing things, the job of making 2 gaskets for the base of the heater also had its turn. Figure 2 shows the dimensions of the joints to be packed, and just how best to cut a gasket for these without wasting a lot of packing was the problem for the engineer. But he finally concluded to make the gaskets as shown in Fig. 3. From a 36 by 36-in. piece of sheet packing we got 2 gaskets, 34¾ in. and 35⅞ in. in diameter respectively. The strip of packing ordinarily used for packing these joints was made as wide as the surface of the joint, 2⅞ in., as shown in A, Fig. 2, but we made the width of the gasket 1 1/16 in. or 1 13/16 in. less than had formerly been thought sufficient. This method also eliminates the necessity of cutting about 150 bolt holes, none of which are the same distance apart in this case, and is quite a job even if they were equally spaced center to center, besides wasting a lot of packing in cutting holes for bolts, the great advantage of having each gasket in one piece and the consequent saving in time. It holds as good as if it were a yard wide—165 to 170 lb. per square inch pressure in this heater. All dimensions are shown in the sketches Figs. 2 and 3 respectively. T. C. R.

DIAGRAM FROM OLD CORLISS ENGINE

I HAVE frequently seen in the columns of Practical Engineer, reproductions of indicator diagrams from modern Corliss engines which show admirable lines and economical use of steam.

I think perhaps we are disposed to believe that the newer, more refined types are the only ones to possess especial merit in that way, so I submit a diagram taken some years since, which, considering conditions,

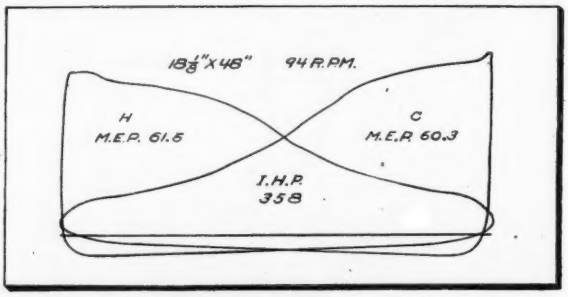


DIAGRAM FROM CORLISS ENGINE INSTALLED IN 1870

seems to me quite remarkable. This diagram does not show the greatest load ever carried by this engines, as it has been indicated when developing about 380 not show the greatest load ever carried by this engine, 18⅛ by 48 in., installed in 1870 and operated at 60 r.p.m. with 70 to 80 lb. boiler pressure.

It was one of the earliest Corliss engines with the wristplate located on the side of the cylinder as is now usually done. It also had the crabclaw-releasing gear but in a somewhat crude form. The dashpots were merely heavy cylindrical weights falling in a pot or cylinder which had a hole in the side near the bottom to permit the escape of air until the weight nearly reached the bottom, then the entrapped air cushioned the fall.

The factory in which this engine was installed, began to require additional power about 1890, and in the next few years several changes were made in order to meet the demand.

First, new boilers were installed and 100 lb. steam pressure carried, then a condenser was put in. The power still being insufficient, the speed was increased to 78 r.p.m. and later the pressure was raised to the limit allowed on the boiler, or 125 lb. Then further increase in demand for power came and the speed was raised to 94 r.p.m., at which speed this diagram was taken. Then for some reason, probably at the instance of a local engine builder, the old cylinder was changed for one 22 in. in diameter; this proved unsatisfactory and the entire engine was discarded for a new one.

In all the years of extreme overloading this engine, there was never a serious breakdown nor any but the briefest delays due to the engine.

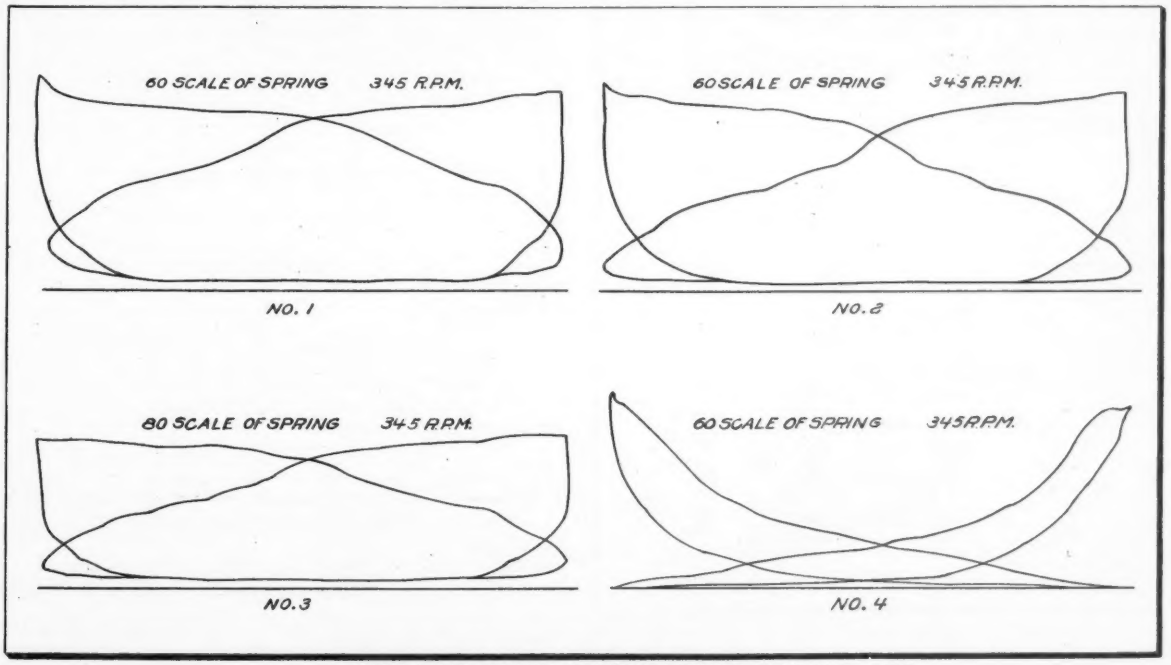
That the economy was high for the conditions will be inferred from the lines of the diagram, which show 358 hp. being developed from a cylinder designed for 125 hp.

Such designs, material and workmanship are certainly of a high order and any builder might well be proud of them. Sabet.

CARDS FOR CRITICISM

I AM enclosing some indicator cards from a 13-in. bore by 12-in. stroke McEwen automatic engine, running 345 r.p.m. I would like to hear what some of the readers of Practical Engineer have to say in regard to them. These are the first cards I have ever taken and would like to have someone make some suggestions how I can better the conditions. I would like to have the horsepower of the largest card; the engine is rated by the makers 102 hp. It drives by belt a 2-phase alternator 2200 volts, and as I have no power factor meter I can't tell by the instruments what the power is. This engine had about all it could handle when I first took charge of it, and in a short time our load began to pick up until I had 22 to 25 more amperes. As I couldn't increase the boiler pressure, the only way I could see how to keep going was to speed the engine up.

The manager even then seemed to think the engine had nothing to do, even though on our peak load if we lost 5 lb. of steam we were down and out. We are carrying 120 lb. steam pressure. One boiler is 66 in. by 18 ft., firing is done by hand and green wood is used for fuel. With such a small margin for steam to fall back on, the fireman hasn't much time for visitors between 7 and 10 o'clock. E. B. O.



CARDS FROM McEWEN AUTOMATIC ENGINE ⅔ ACTUAL SIZE

TROUBLE WITH A FEED-WATER HEATER

THERE are some statements in Mr. Flannery's letter in a recent issue concerning trouble with a feed-water heater that I do not exactly understand. He says that the heater is much too large, and in proof of this states that when he runs the pump fast he gets a temperature of 200 deg. but when running slow gets a temperature of only 190 deg. and if the heater were smaller the water would move faster and he would get a higher temperature. I fail to see how this is accounted for, but I think that he does not get enough steam to heat the water to above 190 deg. but when running the inefficient steam eating pump at high speed he gets more steam, and consequently heats the water to a higher temperature.

The slower the water runs over the pans the more times it will be exposed to the steam to absorb heat, and will become hotter than otherwise, provided there is steam to heat it. He states that he has 4 ft. of water in the heater below the suction pipe, and only 14 in. of available water for use in case the supply is interrupted. If he will examine the inside of his heater he will find a hood covering the suction opening and so arranged that he can pump the greater part of that 4 ft. of water out provided that the pump is below the heater, or the water is not too hot, or if this is not the case there may be a bypass connec-

tion from the suction line to the bottom of the filter chamber unless it may have been left out by mistake in erecting the heater.

Further on, he states that when the filter gets dirty he has trouble in regulating the water. This frequent dirty condition is a very good proof that it is an efficient filter because if it gets dirty in a short time it shows that it is effective in removing the scale forming matter from the water, and his only trouble is that it is not cleaned often enough. It would be interesting to know what make of heater this is.

His main trouble I think is lack of steam to heat the water, possibly only a small portion of the steam is by-passed into the heater, and it needs cleaning at short intervals. I have seen some 10 or 12 different kinds of heaters since I have been connected with power plants, and although I found some that would not heat the water as hot as they should there was usually a good reason for it other than the design of the heater, the usual cause being lack of steam and improper care. J. C. Hawkins.

POWER PLANT LEAKS

THE leaks that are constantly wasting away the steam in our power plants are the ones that run up the cost of operation. We had a plant with a lot of large 4-valve engines, having the valves in the cylinder heads and from all tests it was evident that the engines were using entirely too much steam

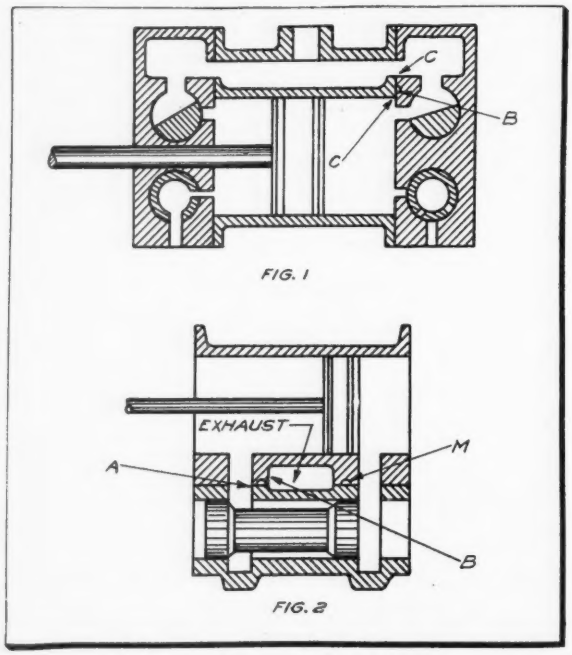


FIG. 1. LEAK IN 4-VALVE ENGINE
FIG. 2. LEAK IN STEAM CHEST OF PISTON-VALVE ENGINE

per horsepower, so we started a careful test for leakage of the pistons and valves, and finding these tight we went further.

These engines were leaking through at the point shown by the letters C, C, in the drawing, Fig. 1. This bridge of metal, in this particular engine, was quite narrow, and this made the problem of keeping packing in the joint most difficult. While there are some brands of packing that will hold in such a place, it requires the very best and it cannot be very thick, as it is impossible to keep a thick sheet in place. You can, however, make such a joint hold by taking a small pointed chisel and cutting a small groove in the surface as shown at B. When this has been done, use a high grade rubber that will vulcanize, make it thin, make the joint and then turn on the steam gradually drawing on the bolts all the time until it has been thoroughly set up and vulcanized. Much care must be exercised in order to be successful in making a joint of this character, in order that you do not blow out the packing material before vulcanizing it.

I have made just such a joint that stood under 125 steam. By taking the ordinary electric lineman's cloth rubber tape and covering it with a good coating of red lead on each side, and the bolting up carefully and by allowing the steam pressure to come on gradually, this rubber in the tape would vulcanize and make a splendid joint—one that is absolutely steam-tight and one that will remain so.

Figure 2 shows another steam chest joint that is deceptive. I have seen this type of engine cylinder wasting many tons of coal daily by the packing being blown out at the points A and B, and the steam simply passing right on through into the exhaust chamber and to the atmosphere. A small groove cut in this smooth surface before putting in the packing will assist in the making of this joint. I have seen this type of engine with a sheet lead gasket in this joint and upon opening up the engine we found that the lead was gone at these bridges. A metallic lead packing requires too much pressure upon the bolts to bring the valve chest up tight enough to hold any length of time. There are, no doubt, engines of this type now, both 4-valve and piston type, that are leaking at these points and they are charged with leaky valves and pistons. C. R. McGahey.

CRITICISM OF CARDS

RELATIVE to indicator cards submitted by E. A. F. in the February 15 issue of Practical Engineer I would say: Compression seems to be too late on both ends and especially on the crank end. Admission is too early on both ends. With a little earlier exhaust closure and a little later admission, the undulation in the compression line shown on all the cards of the crank end will be eliminated. This undulation shows very plainly just where the admission line picks up the compression line.

I do not understand how the engine in question can run satisfactorily with so little compression. Doesn't it seem to strain on the centers? I believe that earlier compression and later admission would improve things generally.

The admission line should show the initial pressure, but in this case the steam line is higher than the admission line, and either a sticking indicator piston or the inertia of water in the indicator connections is responsible for it. I think, however, the former is the more probable. Thos. C. Robinson.

ONE BIG FACTOR IN WINNIPEG'S industrial future, is the completion of the municipal electric development scheme, whereby 60,000 hp. is now available for power for factory purposes. This power, which can be increased as necessity arises, is being delivered at cost, and naturally proving a considerable stimulus to industrial activity.

Successful Kinks From The Plant

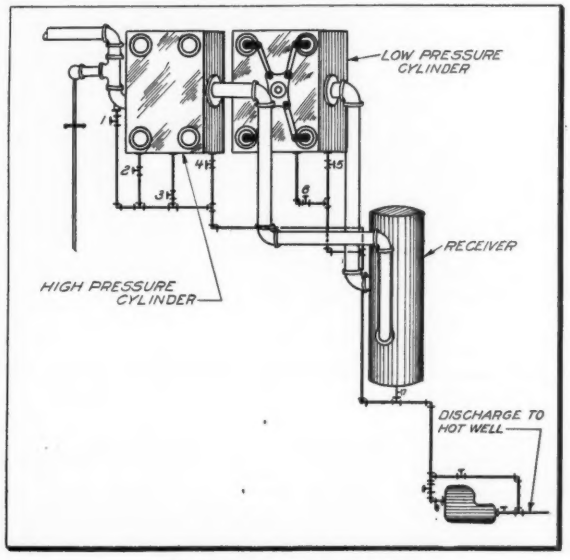
For Saving Time, Work and Trouble

Drains on a Vertical Engine

THE accompanying sketch shows a good way of piping the drains from a vertical cross compound Corliss engine when the receiver is located below the cylinders.

No. 1 drains the steam pipe above the throttle, 2, the high-pressure steam chest, 3, the cylinder, 4, the exhaust chest, 5 and 6, the low-pressure steam chest and cylinder, and 7 the receiver.

Drain pipes from the high-pressure side connect into one pipe which connects with the drain pipes from the low-pressure cylinder at receiver, then the



DRAIN PIPE CONNECTIONS

pipe passes down under receiver, where the drain from the receiver connects into it thence to the trap which discharges to the hot well. The drain from the exhaust chest of low-pressure cylinder (not shown) connects to the suction pipe of vacuum pump.

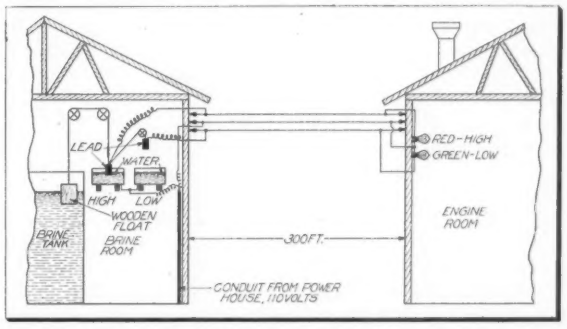
By partly opening No. 1 valve it can be seen with this arrangement of piping it is easy to warm up the engine, as it carries steam to nearly all parts, and at the same time drain it.

After engine is started all drains are closed except Nos. 4, 5 and 7, which drain the parts they are connected to while engine is running. L. K.

Brine Level Indicator

IN the plant where I am employed the engine room containing the ice machines is situated about 300 ft. from the brine tank house containing the brine tanks that the ice machines are cooling.

The pumps circulating this brine through the various parts of the plant are also situated in this engine room. It is quite inconvenient to leave the engine room to ascertain the brine level in these tanks. To prevent overflow and to keep the expansion coils covered with brine at all times keeps a person busy traveling between engine room and brine house, regulating the valves for inlet and outlet.



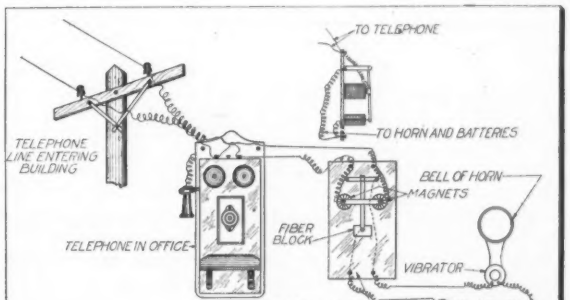
CONNECTIONS TO SHOW HIGH AND LOW BRINE LEVEL

To overcome this inconvenience I have installed a high-low light system in the engine room where I can ascertain the brine level in the tanks by a glance at the lights without leaving the engine room.

The inclosed sketch describes the system of installation in detail. C. E. Anderson.

Electric Horn for Engineers' Use

N the sketch is shown the way I connected an electric horn to the telephone so that the engineers could, at all times, whether in the engine room or outside, be able to hear their call. The Company had used extension bells but they never would ring



CONNECTIONS FOR AN ELECTRIC TELEPHONE HORN

loud enough to overcome the noise so that the men could hear their signal when at any part of the building.

I took 2 bell magnets, the kind used to ring telephone bells and made a gravity relay, this relay has a spring to retrieve the armature.

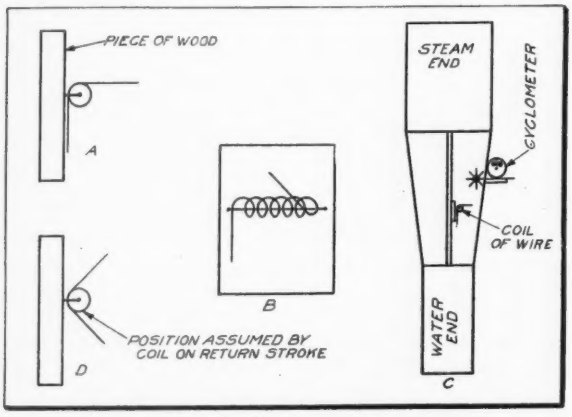
The armature swings free and when not ringing hangs about 1/16 of an inch from magnet thus making a very quick and sensitive action. On the lower end of the armature is a platinum point, also one running through the fiber block, these 2 points make the contact which operates the vibrator on the horn. It is sometimes necessary to connect a condenser with the extra bell magnets but we have no trouble operating the one in use now and up to the present time it has given the best of satisfaction. This outfit can be bought as cheap as the ordinary extension bells and where there is considerable noise is far superior.

L. E. Conroy.

Improvised Stroke Counter

OTHER readers of Practical Engineer may be interested in a cheap and reliable stroke counter. Herewith is shown how I made one out of a cyclometer from a bicycle, I attached the cyclometer to the stationary part of the pump and made a spring as shown in the sketch and attached it to the reciprocating part of the pump. On the forward stroke the spring engages the small radial arms of the cyclometer and on the return stroke, the spring is tilted by the radial arms and thus avoids turning the cyclometer needle in the wrong direction. The spring moves the instrument only on the forward stroke of the pump.

Our pump is vertical, but the idea can be applied to horizontal pumps as well.



USING CYCLOMETER AS STROKE COUNTER

In the figure A shows a piece of wire coiled up and fastened to a piece of wood by a staple. The ends of the wire are set at right angles. B is a front view of coil of wire with staple through it. C shows cyclometer attached to pump and coil attached to crosshead. On the upward stroke the wire engages an arm of the cyclometer and on the down stroke it slips by it and again assumes its position as shown at A, ready for the next upward stroke.

My instrument works as follows: It is for a 28-in. wheel and 16.81 strokes of the pump moves the pointer on the cyclometer one division on the dial. One complete revolution of pointer gives 1480 strokes. By reading the fractions of a division on the dial, I can get within 2 or 3 of the correct number of strokes.

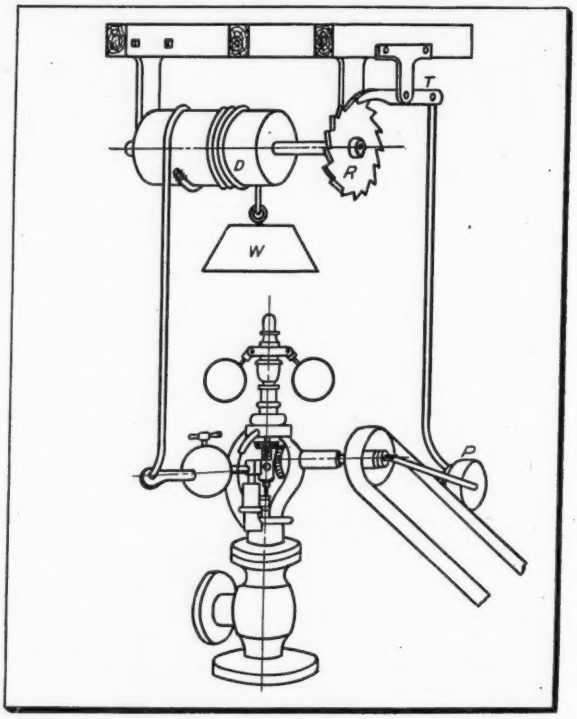
I have had this instrument on our feed pump for a long time and it gives about the same number of strokes for each day showing that the arrangement is reliable.

Frederick M. Perras.

Safety Engine Stop

WHILE passing through a manufacturing plant recently, I noticed the rigging attached to the governor as shown. The sketch shows the method of operation.

The pulley P rolls on governor belt and is heavy enough to release trigger T, to which it is attached by a loose rope, from ratchet R when belt breaks or jumps off of governor pulley. The weight W is then



SAFETY ENGINE STOP MADE IN THE PLANT

free to unwind itself from drum D and at the same time wind the rope and pull up the lever on the governor and thereby stop the engine.

The engineer said he rigged it up from materials he had on hand and did it on spare time.

J. G. G.

A RATE-CUTTING WAR

FROM Tacoma comes news of an interesting situation where the City Power Plant is out after commercial business in competition with the Tacoma Railway and Power Co. The city has 32,000 hp. available, and is carrying now from 8000 to 11,000 hp. The Tacoma Railway and Power Co. has established a low rate schedule for large users; 3 cents per kilowatt-hour to 170 kw., and a reduction in rate for larger amounts down to a half cent for 720 kw.-hr. and over. The city council has reduced its rate to 4½ mills per kilowatt-hour for large users, and expects to get large contracts on this basis. One feature looked for is a considerable load in electric ranges in the homes of citizens.

Spite of this low rate, the isolated plants in Tacoma are not worrying, as many of them are producing in the plants of 75-kw. capacity and under, a kilowatt-hour at the switchboard of not over one cent. It will be interesting to watch the outcome of this rate war and see what finally happens.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

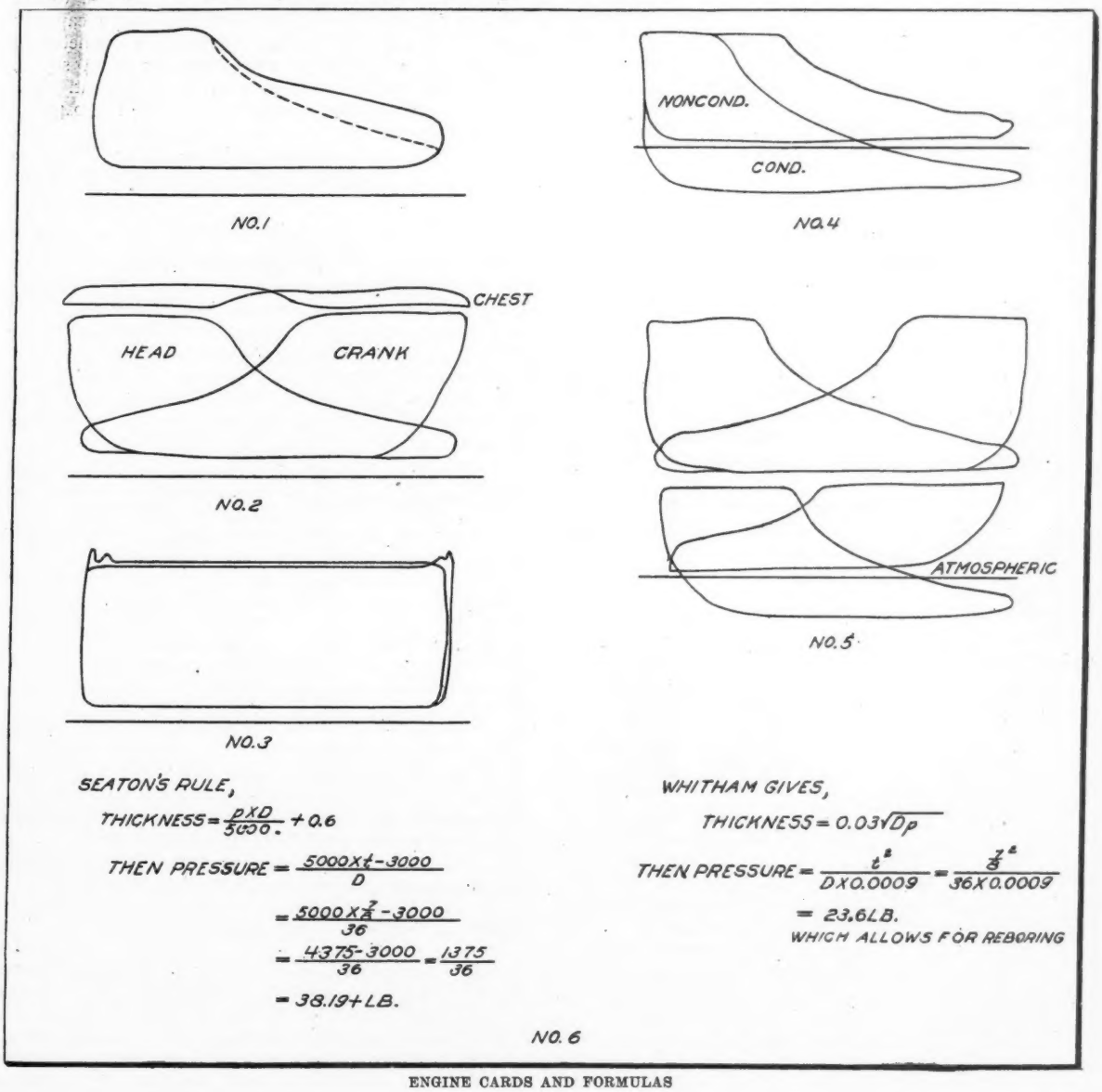
Engine and Boiler Problems

DRAW a diagram showing late admission and a leaky piston.

2. Draw an indicator diagram from the steam chest and the cylinder of a slide valve automatic cutoff engine.

5. What change in valve setting is necessary if the engine is running condensing? Should the valve be set different or not?

6. Draw a diagram of an engine running ¾ condensing.



ENGINE CARDS AND FORMULAS

3. Draw a diagram of a steam duplex pump.

4. Draw a card of a condensing and a noncondensing engine.

7. How is the valve set when running ¾ condensing.

8. Work out by rule the safe working pressure of

a cylinder 36 in. in diameter, ⅞ in. thick, and 5 in. long.

9. What is the safe load on stay bolt plate ¼ in. thick, pitch 6 in. by 6 in., bottom of thread 0.7307 in.?

10. What is the safe load on a head segment of a boiler 66 by 23 in., with 13 1¼-in. diagonal braces welded. P.M.

A. In the figure, 1 shows the card with late admission and a leaky piston; 2 shows the head and crank end cards for an engine with the steam chest card above them; 3 shows the cards from the 2 ends of a duplex pump; 4 shows the cards for an engine condensing and noncondensing — the condition of cutoff being that it must be lengthened so that the area of the noncondensing card will be the same as that of the condensing.

For the sixth question, a ¾ condensing engine is one which has one end of the low-pressure cylinder running noncondensing—that is, exhausting at high-pressure to furnish steam for heating or industrial work. One low-pressure card will, therefore, be with a fairly short cutoff and the exhaust to the condenser. The other low-pressure card will have a much longer cutoff, and will exhaust at a pressure above atmosphere. In the cards as drawn in sketch 8, the receiver pressure is rather higher than it should be. This practically answers also question 7.

8. According to Seaton's rule, the thickness of an engine cylinder should equal boiler pressure, times the diameter, divided by 5000 and 0.6 of an inch added to the equation. The expression as shown in the figure under 6 would then be solved for pressure, and we should have the pressure is equal to 5000 times the thickness, minus 3000, divided by the diameter in inches—which works out in your case to 38.19 lb.

Whitham gives for a rule which allows for 2 reborings, the thickness equals 0.03 times the square root of diameter times pressure. Solving this for pressure, we have that the pressure would equal the thickness squared, divided by the diameter, times 0.0009, which in your case works out to 23.6 lb.

Both of these pressures seem low, but they allow for possible unevenness of casting and reboring of the cylinder to take care of wear.

Of course, the safe working pressure might be figured out by the rule for a boiler, which would be that the pressure is equal to twice the thickness, multiplied by the safe tensile stress, and divided by the diameter in inches. In your case, allowing a safe tensile stress of 10,000 lb. to the square inch, this would work out to 484.5 lb. This is, of course, an entirely different calculation from the other one, because the tensile stress allows for a good steel plate and to take care of the pressure only—while the engine formulas are for cast iron and allow for wear in the cylinder.

7. The area at the bottom of the thread is 0.7854 times 0.7307 squared, or 0.419 sq. in. Allowable stress on a stay bolt is 6500 lb. to the square inch, and 6500 times 0.419 equals 2724 lb. With stay bolts on 6-in. centers, the area supported is 6 times 6 equals 36 sq. in.; and the pressure per square inch allowed would then be 2724 divided by 36, equals 75.5 lb. per square inch.

10. The area of the segment to be supported by bracing in a boiler, is equal to 4/3 times H squared, times the square root of (2R divided by H, minus 0.608). In this expression, H is the height of the segment from tubes to shell, minus 5 in., and R is the radius of the boiler, minus 3 in.; and in your case, H equals 23 minus 5, equals 18, and R equals 33 minus 3, equals 30. The area then works out to be 713 sq. in.

For 1¼-in. stays, the Massachusetts rules allow 7500 lb. per square inch for steel, and 6500 lb. per square inch for wrought iron. The area of the 1¼-in. is 1.227 sq. in., so that the load per stay for steel would be 1.227 times 7500, equals 9170 lb.; 13 stays would then carry 9170 times 13, equals 110,400 lb. The pressure allowable would be 110,400 divided by the area 713, or 154.5 lb. per square inch. A. L. R.

Standpipe Problem; Volume of Barrel

I WISH to know how to make a circular tank to hold about 5000 gal. of water, the tank to have straight sides or the diameter to be the same top and bottom and one whose sides are tapered, the diameter of the top being 10 or 12 in. less than that of the bottom.

Please give me the rule for finding the cubical contents of a barrel when the middle of the barrel is larger than the top or bottom. T. J. T.

A. For the standpipe, it will hold 7.48 gal. to the cubic foot; 5000 gal. will, therefore, call for a capacity of $5000 \div 7.48 = 668$ cu. ft. Assuming a diameter of 10 ft., the area would be $10^2 \times .7854$, or 78.54 sq. ft. Dividing 668 by this gives 8.52 ft. as the height. The pressure at the bottom would then be $8.52 \times 0.434 = 3.7$ lb. per sq. in.

To find the thickness required, we have: Thickness equals pressure times diameter, divided by 2 times the safe tensile stress, or

$$\frac{3.7 \times 120}{2 \times 12{,}000}$$

This gives a thickness of 0.018 inch, which is so thin that it is evident that any kind of a boiler sheet will stand the pressure. Of course, on the bottom of the tank it must be well supported because there you have the flat plate to take care of. The only really good way is to use the hemispherical bottom in which case the same thickness plate can be used for the bottom as for the sides.

If the tank should be made of wood, cypress or pine plank 2 in. thick should be used, from 8 to 10 in. wide, beveling the edge so that they will make fairly good joints when set up. The bottom should be tongued and grooved into the sides.

For a tank to be made smaller diameter at top than at bottom, bands can be made continuous and simply driven on to make the tank fairly tight before letting in water. If the staves are vertical, with the same diameter at top and bottom, bands should be made with some means of taking up, either by turn buckle or ears and bolts. When the tank is first filled, to prevent excessive leakage meal or bran should be thrown into the water.

In regard to the barrel, the rule is: Add the large diameter and the small diameter and divide by 2. Square this quotient and multiply by the height of the barrel and by the constant 0.79 and also by 7.5. The dimensions are all to be measured in feet and the contents will be given in gallons with a close approximation.

A. L. R.

THE THIRD INTERNATIONAL CONGRESS of Refrigeration will be held in Chicago September, 1913, and will be attended by delegates from all parts of the world. Papers will be presented on many subjects of practical interest in the field of refrigeration, and the opportunity for learning fundamental facts and the best current practice, will be one of a lifetime. Papers are desired for presentation from those who have new information of value to the industry, and suggestions for such papers should be sent to Peter Neff, Chairman, Canton, Ohio.

Problems For Discussion By Readers

What Would You Do If You Had These Conditions To Meet?

Re-fluing Boiler

CAN the readers of Practical Engineer give any advice in regard to re-flueing a traction boiler?

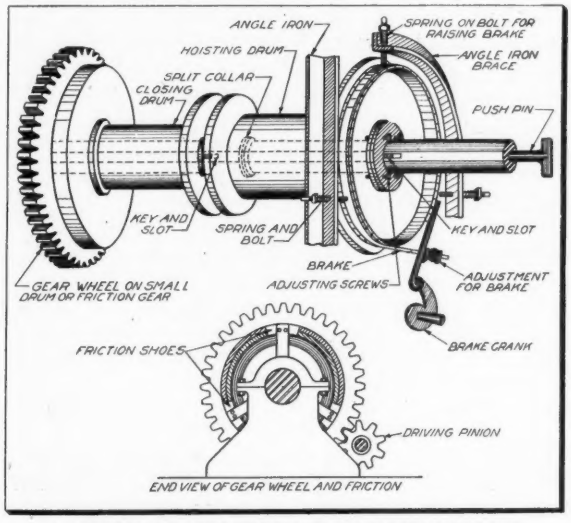
J. E. M.

Air Compressor Problem

WILL someone please inform me if there are causes other than the piston striking the heads of an air compressor that might cause them to break? The compressor to which I refer is a small motor-driven single-stage machine. E. H.

Clam-Shell Digger Problem

ACCOMPANYING sketch shows the drums and frictions of a McMilar clam-shell digger. I should like to have some reader suggest the best and easiest way to keep the apparatus in order, especially the small brass friction which refuses to take hold and wind the hoisting cable.



DRUMS AND FRICTIONS OF CLAM-SHELL DIGGER

I should also like to know what is the best way to prevent the oil from traveling through the shaft and what is the best lubricant to use on the thrust bearing.

Is there any suitable preparation on the market for use to prevent the brass slippers on the gear end of the drum from cutting? H. Beverley.

Vacuum Troubles

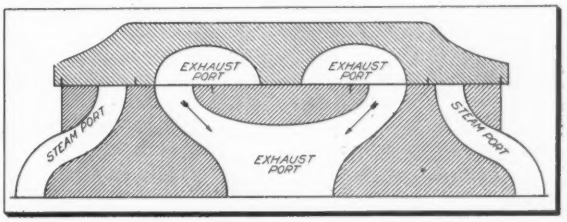
I HAVE been requested to answer a question asked by one of your correspondents regarding poor vacuum obtained with a condensing equipment, connected to a 2000-kw. Curtis turbine. I believe the cause of his trouble is in hot well pump; the condensate is evidently not being removed as it should be, which may be due to glands not being properly sealed.

If the condensate be allowed to rise in the condenser, it may be carried over to the dry vacuum pump, causing labor and breaking of rods described, and at the same time lower the vacuum. If this is not cause of trouble your correspondent should write to the Worthington Co., giving set of readings taken when vacuum is low; these should consist of steam pressure and temperature, condenser vacuum and temperature barometer reading, circulating water inlet, and outlet, at different loads, and remarks as to the operation of the different pumps. If he will do this I am quite sure the cause of trouble will be located, and a remedy suggested. Will H. Phillips,

(Erecting Dept. Henry R. Worthington Co.)

Valve Problem

ACCOMPANYING is sketch of a valve and seat of a 12 by 16-in. throttling engine that is under my charge. I should like to hear from engineers through the columns of Practical Engineer in regard to the change I purpose to make. I think this valve is ¼ or ⅜ in. too long, and inside lap is excessive. I think there should be ⅝ in. removed from it, as I have marked on sketch. Cutoff takes place at about 10 in. of stroke. I think compression takes place too early and exhaust release too late.



SUGGESTED CHANGES IN VALVE

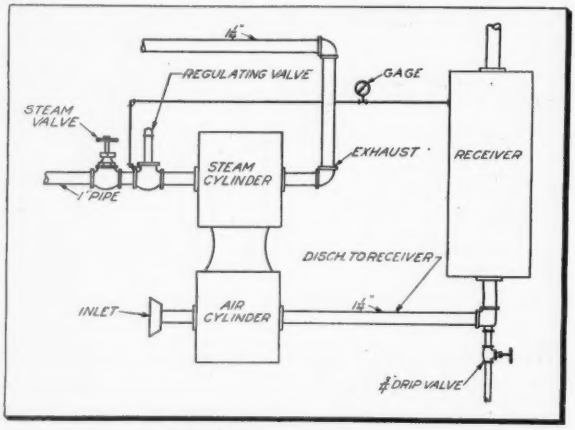
This valve originally was 12¼ in. long and there has been ⅜ in. riveted on each end. Valve has a 4-in. travel. We are not getting the power I think we should from this size cylinder, and I think this change will put it right; but it will require a little more steam, of which we have plenty.

E. H. Lewis.

IN A RECENT article, an advertising writer refers to women as "the spark plugs that start the dynamos of buying." He doesn't write machinery advertising, though;—sells "art" matting squares at $1.38 and solid oak rockers at $1.42 and sich.

Air Compressor Problem

I SHOULD like information regarding this air compressor. It is located in the basement of the rope tower connected up as shown. The regulating valve is set to blow at 90 lb. It is piped up to blow out generators and motors only.



COMPRESSOR AND PIPING

We get a little water at the drip when we start pump, but at the nozzle of the hose we get considerable water, making it unfit to blow out generators. Where the machine is located it is not damp, although the room is heated. Will some one suggest a remedy?

E. S. R.

Practical Questions

IS there any part of the piping to a boiler, in which the pressure is greater than indicated by the steam gage?

2. If the efficiency of the longitudinal joint was 93 per cent, and that of the girth seam 49 per cent which would you use in calculating the safe working pressure?

3. In a 3-course horizontal return-tubular boiler why is the middle course put inside the other 2?

4. Which is preferable, a round or conical rivet head, and why?

5. In the formula T.S., tensile strength of shell plates, in pounds, times t, minimum thickness of shell plates in inches × %, efficiency of, longitudinal joint divided by the radius R times F.S., lowest factor of safety allowed, for determining the safe working pressure, R is one-half the inside diameter of the outside course; why is the outside course specified?

6. In a double butt strap joint, why is the narrow butt strap on the outside?

7. The State of Massachusetts allows 42,000 lb. per sq. in. as the shearing strength of steel rivets in single shear, and for double shears only 78,000; why do they not allow 84,000?

8. If a steel plate was high in homogeneity and low in ductility would it be suitable for boiler plate?

9. Why is a lap seam considered dangerous as a longitudinal joint?

10. Suppose a set of new tubes came for your horizontal return-tubular boiler, and they were found to be from ⅛ in. to ¼ in. too short; how could you use them?

11. What is a bag on a boiler and how is it caused?

12. Why are the tube ends of fire-tube boilers headed over while those in water-tube boilers are only flared out and not headed?

13. What is the difference between a hard patch and a soft patch?

14. Should a hard patch be put inside the boiler or outside?

15. What kind of oil would you use in your engine cylinder?

16. Suppose you took charge of a battery of boilers that had been shut down for some time, how could you be ready to start up in 2 days, the boilers being badly greased and bagged?

17. If you had charge of several boilers in a plant where there was no night watchman, and you went home after banking the fires, if, on returning in the morning, the gage on one boiler showed 60 lb. of steam, and on the other 20 lb., which fire would you break up first?

18. What is a wet bottom boiler?

19. Suppose you had charge of a small plant, consisting of an engine, a boiler, a closed feed-water heater and a pump. If you got a violent water hammer in the exhaust pipe of the engine, what would you say was the matter, and what would you do?

20. Would you close the throttle in that case?

21. Suppose a bucket trap were connected to a system to be drained, and when the trap was started the bucket dropped to the bottom and remained there, the water blowing right through for a time, after which the trap started to work all right, what could you say to account for it?

22. Suppose you had a wet vacuum pump, direct steam driven, in which the piston moved with a jump at the beginning of each stroke, but after moving several inches it steadied down to normal speed, what would be the matter?

23. What is an induction heater and why is it used?

24. Does the cam shaft on the Putnam engine run the same number of revolutions as the main shaft?

25. How could you tell if the lead was constant or variable, with any type of shaft governor?

26. Suppose you saw a single eccentric Corliss engine, which alternately knocked off the valves, and hung on full stroke, what would you think?

27. To save time, we will eliminate the usual remedies, such as adding another eccentric, adding a condenser, etc., what could you do by way of adjustment that would relieve the conditions?

28. What is lap for on the steam valves of a single eccentric Corliss?

29. If you shortened 1 rod and lengthened the other, to the governor on a Corliss engine, what would it do?

30. How could you tell if a Fitchburg engine would race with the load thrown off?

31. How could you change the speed of an engine with a shaft governor?

32. Why is the spring of a safety valve made of square stock instead of round?

33. Why is a feed pump called a feed pump?

34. Under what principle of mechanics would damper regulators, such as the Locke and Spencer, be classed?

35. Suppose you had charge of a Cameron duplex pump and one of the valve stems should break, what would you do?

36. Can you test a vacuum breaker under working conditions?

John A. Levy.

(Answers will appear in an early issue.)

Piston Rod Packing

IN a recent issue of Practical Engineer H. M. Hastings asks for an opinion in regard to his piston rod packing blowing out, and states that he has never heard of the nuts working off. My experience with a certain 20 by 36-in. Corliss engine has been that the nuts will work off provided there are no lock nuts on the studs, and especially when using diagonal or sectional packing.

On this engine the rod was packed with a class of packing that does not require the nuts to be drawn up tight because the steam pressure against the wedges forces them apart, and on the return stroke, especially if the rod is a little dry, the packing may be pulled away from the gland. The constant reciprocating motion will cause the gland gradually to work the nuts off, if they are an easy fit on the studs. The remedy in this case was to put on a lock nut.

The engine operates with a steam pressure 150 lb., and much trouble was experienced from the use of ⅞-in. soft packing; the rod was 3½ in. in diameter. The company was partial to the use of cheap packing, and many times that purchased was entirely unsuited for the work, and frequently it was necessary to shut down during working hours to repack the rod.

One certain brand of wire inserted asbestos packing, on 2 trials lasted about ½ day, most of it working out along the rod. Another time, in less than 1 hr. after putting in the new packing, the rod was smoking hot, although in all cases especial care was used to put the packing in as it should be, seeing that the rings had room for end expansion, and that the gland was not screwed up too tight. The nuts could be reached while running to adjust them if necessary; cylinder oil was also used on the rod outside the gland.

I also had the same trouble with an air compressor, using square high-pressure asbestos packing; the nuts would work off allowing the packing to blow out, causing a shutdown. This trouble was also stopped by using lock nuts.

Mr. Hastings states that there was only ⅛ in. of the bolt left to screw the nut on, and it may be possible that the packing in expanding exerted pressure enough to strip the short thread on the stud; this, however, would be evident when the gland was replaced.

There were several good brands of packing that give excellent service, but the price was too high to suit the purchasing agent who knew nothing about it. In 6 months the rod used up $38.00 worth of so-called packing, then after much talk and discussion I persuaded them to put on metallic packing which cost $35.00, and aside from the first week it has not been touched for over 2 yr.

Packing may be either drawn out along the rod, or the nuts may work off, allowing the gland to come off. Possibly the regular day engineer's reason for saying that the nuts worked off was that he found them off when repacking the rod. J. C. Hawkins.

Massachusetts Examinations

IN reply to Mr. Dixon's article bearing on Massachusetts fireman's licenses, I wish to say that with some points that Mr. Dixon specifies, such as cutting in a boiler, position of water column, bottom blowoff, etc., I am familiar. I would like to know the manner of cutting out a boiler; why are rear heads flanged in and front heads flanged out; am I correct when I say that in case of low water and the fusible plug gone, to bank fires, or deaden them with wet ashes, thereby bringing down the steam pressure? In regard to the question: "If the manhole plates should fall in with 60 lb. of steam on, am I right when I claim that what holds good for a handhole plate falling in, holds good for a manhole plate?" My answer is that a manhole or a handhole plate cannot fall in with steam pressure in the boiler because they are so situated on the boiler that the steam pressure is against their falling inward. Subscriber

Steam Engine Trouble

ON page 195 of the February 1 issue of Practical Engineer, a problem for discussion refers to a 14 by 20-in. single eccentric Corliss engine tandem connected to an ammonia compressor. It says that after starting up, the governor hunted badly. I have had similar experiences.

Probably the most frequent trouble in governors is binding in the governor rod bearings; because the pins are too short when the nut and washer are drawn up tight, side binding results. This will cause a variation of the engine speed in proportion to the friction produced and a little friction will cause a noticeable variation in the machine. Excessive binding will cause severe racing. This fault applies to the governor connections and to the cam lever connections. The remedy is to adjust every rod so that it can be freely moved sideways on the pin.

The placing of the knockoff cam lever bearing between the steam arm and the double arm, and exposing it to a side thrust from each, is wrong; the knockoff cam should be operated on a separately flanged bearing.

Racing is sometimes caused under variations of load and even under less exacting conditions, and a stiff governor will sometimes allow the engine to race, due to slow speed in the governor. This is cured by decreasing the size of the governor pulley and adding a weight to the governor until the engine picks up its right speed again, afterward weighing the weight and then adding the equivalent weight permanently to the governor in whatever form the governor best allows. Before doing this it would be wise to make sure there is no undue friction in the valves, by removing the weights and balls and also disconnecting the valve gear to see if the arms, after being raised as high as they will go, drop freely of their own accord; if on moving them up and down there is no binding or sticking, it is evident there is no undue friction there and the trouble is elsewhere.

A trouble engineers often experience is that of the oil getting low on the governor gag pot; this should be the first place to look for the cause of a racing engine. For evaporation a little oil should be added to the pot occasionally. Perhaps the trouble is caused from the ammonia compressor discharge valves sticking, in which case they should be cleaned.

If the discharge valves stick in a cross connected or a tandem connected engine this will make the engine race. They can sometimes be started by closing the suction and opening it up quickly for a turn or two; this will start the valves and stop the racing. If on a belt driven machine the engine will also race and if a motor is used and a belt drive, the belt will have flopping spells, due to more speed at one-half of the revolutions and can often be stopped flopping and the valves can be started by pulling the controller back a few notches and throwing it forward quickly. This has been my experience and I hope that it will help in this case. Martin McGerry.

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SELF CONTAINED BOILER UNITS

Combining the superheater with the boiler is a common practice which has much to commend it on the score of low cost of installation and attendance. Something is sacrificed in the matter of flexibility of operation and possibly in heat efficiency; at any rate, European practice has favored the separate superheater more than the combined.

But in the recently completed Brandenburg station there is a distinct reversal, and not only superheater, but economizer is made part of the boiler unit. This hitching of the economizer direct does not effect the economy in attendance that comes from the direct superheater, but it materially lessens first cost of the plant, keeps the active part of the installation balanced, and avoids depriving the whole plant of the benefit of economizer saving when it is necessary to repair or clean an economizer section. The innovation seems like a promising advance in method.

EMERGENCY BOILER FEEDING

Full feed or none is the stumbling block which has barred the injector from stationary plants as a regulation boiler feeder. Also, the difficulty of handling hot water has been against it. But as an emergency standby, neither of these objections holds. Having to start up and shut down the injector occasionally is a small matter as compared to a shut down, and even several per cent efficiency can well be sacrificed at a critical time.

In space required, and capital on which interest, taxes and depreciation must be charged, the injector easily distances the extra pump, and used as a means to help out in overload periods the large standby injector will permit a smaller feed pump for regular service, and will be benefited by the regular periodic use.

The system as described by Mr. Hogate has possibilities of wide application worth while considering when installing or rebuilding the boiler plant of even the largest stations.

TELLING IT ALL

The main features of a plant or a job are the ones that attract attention and usually get described. But the little things, the bothersome snags that are not thought of until right on the work are the points in which the man who has "been there" has a big advantage over the novice.

It is for this reason that articles which go into complete detail, such as that by Mr. Olberding on his storage battery plant are of the greatest help. Such records of actual experiences give the man who reads them a reserve fund of resources to draw on to meet the unforseen and "impossible" that make him efficient and help him "get there."

We leave it to you who read this, is it not so?

Well, then, send in your story of how you did it with the same full and helpful detail.

ACIDITY IN LUBRICATORS

AS there is in this country no standard testing laboratory or authoritative body which has final decision in the matter of announcing results of tests, the user is apt to become very uncertain as to what lubricant is really the best for his use. Of course, he has the opportunity at all times of writing for samples in order that he may make comparative tests himself as to which acts the best for him. This seems to be the most practical way of learning just exactly what a lubricant will do and it is if all things are equal.

Generally this practical test discovers 2 things. First; does the lubricant keep the bearings cool? Second; does it take more or less of this lubricant to do it than of the material with which a comparison is made? One step further should be taken and that is to determine the acidity of the lubricants, for it is the amount of acid that a lubricant contains which determines the amount of harm it can do in pitting of bearing surfaces.

Free acid in an ordinary grease will slowly attack the shaft, and always first where there may be a slight fault in the metal, starting a chemical reaction and forming a new compound which may be soft enough to crumble away or hard enough to break off. If this foreign element is gritty as it may be, there results grinding and cutting which opens up a still better field for the remaining acid grease to eat into the vitals of the shaft.

A further action which is not apparent until the destruction begins, is a lime deposit so thin and so transparent that it practically takes the color of the bright surface of the metal. It is this glass-like transparency that hides the trouble, the coating not showing, but being easily fractured, thereby creating the destructive factor.

Grease as delivered from the maker will generally be found to range from a light yellow to a straw yellow and sometimes with a brownish tinge, if allowed to stand, and it gradually turns color until it finally becomes a mass of heavy red, it is a sign of oxidation and indicates that acids have formed from the substance used in making the body of the grease. Therefore, simply watch the color of the material and also look at the grease cup after you have used it, to see if a residue remains.

Tallow greases of a light yellow color without foreign matter do not change color or body in any manner, and contain nothing that cannot be used as a lubricant so that there is no residue left in the grease cup.

NEWS NOTES

PREPARATIONS ARE GOING forward steadily for the Panama-Pacific Exposition, which will be opened on February 20, 1915. Although this is 2 years ahead, already the first work has been started and the exposition headquarters building is completed. Fourteen main exhibit buildings will be erected, contracts for which will be let at the rate of 2 each month, so that all buildings will be completed by June, 1914. Twenty-six American states have selected sites for their buildings, and also 26 foreign governments have accepted the invitation to take part, among these being Japan, Canada, Great Britain, France, China, Sweden, Spain, and the Argentine Republic.

Applications for concession space have come in to the number of more than 2000, all being of an educational character, such as a reproduction of the Grand Canyon by the Santa Fe Railway, a working model of the Panama Canal and a reproduction of the Grand Trianon at Versailles. The exhibit space asked for has already exceeded the amount of space available. Many of the exhibits will range in value from $250,000 to $300,000.

THE ENGINEERS' SOCIETY of Western Pennsylvania, at its annual meeting in headquarters in the Oliver building in Pittsburgh, on January 21, named Sergius P. Grace as president. The other officers elected were: Vice-president, A. R. Raymer; treasurer, A. E. Frost; directors, W. E. Snyder and E. H. Haslam.

Charles M. Schwab, head of the Bethlehem Steel Co., and F. Hopkinson Smith, the noted author, the banquet committee reported, were the speakers at the annual gathering of the society in the Hotel Schenley on January 27. John A. Brashear, Pittsburgh's famous scientist, was presiding officer.

BILL IS NOW before the Ohio Legislature for the establishment of an Engineering Experiment Station at the Ohio State University, to make technical investigations and supply engineering data, along the same line as the Engineering Experiment Stations in other states.

It would certainly seem that in a state where there is as large industrial interest as in Ohio, the establishment of such a station should be favored by every engineer and manufacturer.

AN ORDINANCE making provision for the abatement of the smoke nuisance in Knoxville, Tenn., was recently presented to the board of city commissioners by the local society of stationary engineers. No definite action, however, was taken pending the addition of a section to include locomotives.

FOLLOWING A LONG ESTABLISHED custom, the salesmen and department managers of the H. W. Johns-Manville Co., some 600 in number, were assembled in annual convention during January and February at the large cities throughout the country, to study the products which the company manufactures and which they are selling. Some 300 products were taken up and their advantages pointed out by specialists in each line. At each convention there was a banquet at the close, as a fitting ending.

ONE EVENING in February about 75 consulting and operating engineers, representing the organizations of New England, met at the Quincy House in Boston to discuss the formation of an Isolated Power Plant League. This was the result of a movement started in January, and W. A. Campbell was chosen as temporary chairman.

The object of the meeting was stated by him and the record of the first meeting in January was read by the temporary secretary, E. F. De Gruchy of the New England Association of Commercial Engineers. An address was then given by H. D. Barker of the Massachusetts Electric Light & Gas Commission in which he stated that he hoped that whatever was decided on by the members present, truth would be their main object.

The motion was then made and carried to form a permanent organization to be known as the Isolated Plant League of New England, and it was then voted that the chairman should appoint 5 members as a committee to frame a constitution and bylaws, the following men being chosen: H. E. Stone, Arthur Morse and W. W. McLain, Boston; A. Huddell and P. E. Tirrel of Haverhill.

The election of permanent officers was considered, but was objected to because the constitution and bylaws were not yet adopted, and temporary officers were chosen to act until such adoption. These were chairman, W. K. Campbell, secretary W. W. McLain. The meeting then adjourned subject to the call of the chairman.—W. E Chandler.

Power Apparatus in Shop and Market

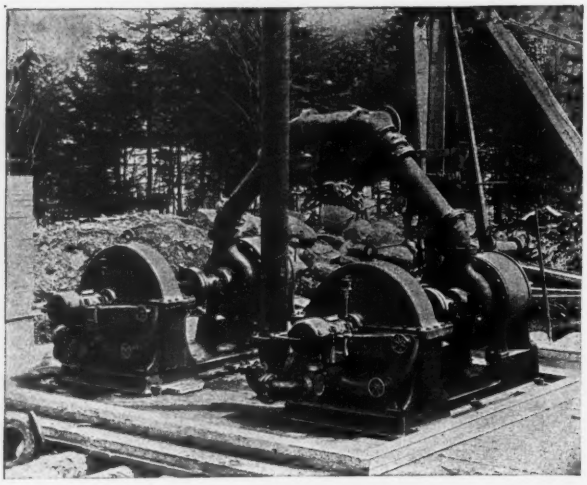
New Ideas In Making, Buying and Selling

PUMPING A DAM

Novel Method of Digging, Carrying and Placing a Dam in a Continuous Stream of Material

AN engineering feature of decided interest in the building of the Abbott Brook Dike, an earth dam located on the westerly side of Sawyer Lake, the new reservoir formed by the Aziscohos Dam across the Magalloway River at the headwaters of the Androscoggin River, was the placing of practically 75 per cent of the dam by sluicing methods using turbine-driven centrifugal pumps.

This dike is 900 ft. long, 165 ft. wide at the base, and about 16 ft. wide at the top and has a 6-in. plank core, or diaphragm, composed of 2 layers of 3-in. plank. The total volume of the dike is 46,000 cu. yd. of which



THE TERRY TURBINE AND ALBERGER PUMP SLUICING OUTFIT

amount 1600 yd. were placed by manual labor to form the toes of the dike and for the puddle fill at each side of the timber core in the cutoff trench. Of the remaining 44,400 cu. yd., 31,165 cu. yd., or the entire embankment to an elevation above normal water level, were placed by hydraulic sluicing methods, similar to those used in the big earth dams of the West.

For this work a plant consisting of 2 150-hp. Terry turbine-driven pumps was used. The turbine units were direct-connected on the same base by flexible couplings to 3-stage, 8-in. Alberger centrifugal pumps and were designed to run at speeds ranging from 1800 to 2000 r.p.m. The main pressure line from the pumps to the burrow pit was 600 ft. long and 10 in. in diameter. The branches connecting this main with a 2-in. monitor hydraulic giant were 350 ft. long and 7 in. in diameter. The pipe, a No. 16 gage spiral riveted, was fitted with flexible joints and anchored at all angles and joints, where subject to unusual strain, with wire lines fastened to dead men or stakes driven in the ground. The force of the water leaving the nozzles under high pressure was so great that although the nozzles were securely mounted on swivel bases, a long lever had to be attached to each nozzle to enable one man to control it. Even then under certain conditions 2 men were required at a nozzle. Steam to run the turbines was furnished by a battery of boilers. The battery consisted of 2 50-hp., 3 40-hp., and 3 30-hp. boilers and a multicoil feed-water heater. The boilers were all of the horizontal type and were asbestos covered to conserve as much heat as possible on account of the high cost of fuel.

In sluicing, 2 powerful water jets under nozzle pressure of from 2 to 80 lb. per sq. in. from the 2-in. hydraulic giants were directed against the bank in a burrow pit at the northerly end of the dike. At the highest pressure, these quickly loosened the earth, eating into the bank almost ravenously, and the resulting mixture of earth, stone and water was guided to the head of the main flume, then through the main flume and the laterals or distributing sluices to the place of deposit in the fill. The flumes were rectangular wooden structures supported on wooden trestles and had to be built with definite even slopes from the burrow pit to the fill. The main flume was about 1000 ft. long and the main trestle about 40 ft. high at the tallest point.

The laterals were arranged to discharge at the edges of the fill and levees or dikes were built to direct the flow or incoming material from the edges to the center of the fill. In this way the loose stones and coarse material remained at the edge and the finer particles and silt were carried by the water toward the center. The result is a bank having the coarser and more porous material at the outside, grading gradually to the finer impervious material at the center. The whole mass is packed as solidly and securely as in its original bank formation, and the resulting dike is better than could have been produced by the common method of excavating, transporting, filling, and compacting.

Although turbine-driven pumps were considered somewhat of an experiment for this line of work, these units added considerably to the successful completion of the dam in the short time of about 82 full days. The Terry turbine-driven pumping outfit is especially suited for this class of work, as it maintains a steady water pressure at the nozzle, and has all parts completely enclosed so that the operation of the machine will not be interfered with by dirt or dust.

As the location of this dam is some 40 miles from the nearest railroad station and the intervening roads are mountainous and often impassable for teams, the light weight and the small space occupied by these turbines was of particular advantage. The site of the dam so far from the railroad also made it extremely difficult to get a sufficient supply of coal and what little could be obtained was at a minimum cost of some $20 a ton. Such a price was prohibitive and it became necessary to rely on

wood for fuel. 1860 cords of wood were burned and counting the 55 long tons of soft coal used as equivalent to 2 cords each of wood made about 1970 cords of wood burned in all.

The material moved by sluicing was a glacial drift composed of gravel, sand, clay, and small stones, and was so firmly compacted that it was found advisable to resort at times to dynamiting to loosen the materials. Holes were drilled about 8 ft. deep and 8 ft. apart and about 6 lb. of 60 per cent dynamite used per hole. These charges were set off in batteries of from 3 to 7 holes to a firing. Steam pressure at the boiler ran from 80 to 105 lb. gage and the pump pressure was about 45 lb. per sq. in. down to 25 lb., depending upon the elevation, averaging about 45 lb. per sq. in. with a 2-in. monitor discharge stream.

Sluicing was carried on for 32 10-hr. days and for 68 24-hr. days, which is equivalent to 82 full days. The men worked on 2 shifts of 12 hr. each, working week days and Sundays continuously, the only stops being for unavoidable delays, cleaning, and repairs. The average yardage placed per day was 380 cu. yd. and the best weekly record was 3891 cu. yd. or an average of 556 cu. yd. a day. The record was determined by weekly cross-sectioning the embankment. The volume of solids moved in the water averaged better than 6 per cent under normal conditions.

PRESERVATION OF A ROPE DRIVE

IT is well known that rope drives do not often fail because of surface wear. Failure usually begins at the core where the severest rubbing of fiber against fiber occurs. This may be proved by examining any such rope that has failed. It will be discovered that the core and inner fiber of the strands have worn into short lengths, or, if the strands are still continuous, into a weak condition. Obviously, then, the proper way to preserve a rope drive is to lubricate these rubbing fibers and prevent them from grinding themselves thin and weak.

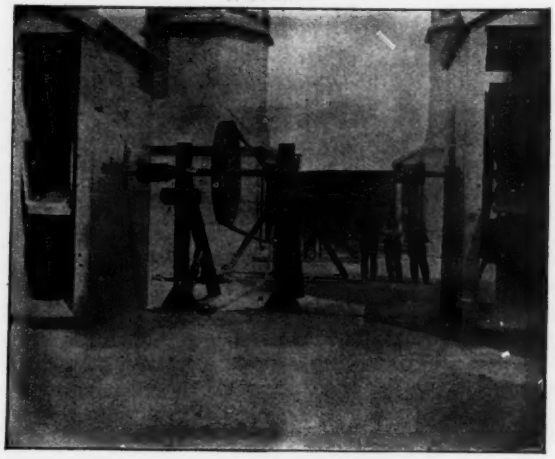


FIG. 1. ROPE DRIVE EMPLOYING 1500 FT. OF MANILA ROPE

Figure 1 shows a 1500-ft. manila rope which for nearly 5 yr. was located out of doors on the roof of a high building in the open country where it was exposed to storms from Lake Erie, winter and summer, and to all other hardships connected with direct exposure to sunshine, dampness, freezing, dirt, etc.

The owner of this plant employed Cling-Surface treatment as the method of preserving pliability, cleanliness, life and non-slipping qualities of their ropes. The success of this treatment is proved by the well-preserved appearance of the heart of a section of one

FIG. 2. STRANDS OF ROPE AFTER 5 YR. OF SERVICE

of the above mentioned ropes, Fig. 2, after its 5 yr. of service. The only indication of wear is at the surface of the rope and this wear is so slight that its effect on the strength of the rope, may be considered negligible.

METAL INSURANCE

By L. M. Stocking

THIS may be an unfamiliar term, yet it is the thing to do, and live owners of property are adopting it. Metal insurance by protective paint is what is referred to. Structures should not be painted spasmodically but regularly. Metal surfaces should be inspected at different intervals and a paint applied which will give the longest service, in order to save the labor cost of frequent repainting.

A structure well painted is insured against decay and depreciation, while a structure run down entails great expense in an effort to bring it up to satisfactory condition, and even then the effort is likely to be inefficient. Regular inspection and paint which lasts long is the solution to the problem. A silica graphite paint made by the Joseph Dixon Crucible Co., is available in 4 colors, and equally suitable for metal or wood. It is composed of a mixture of silica and graphite, and used from the original package gives great endurance and satisfactory metal insurance.

SPARK GAP LIGHTNING ARRESTER

STATIC protective apparatus, to be effective, must act exactly like a safety valve: it should allow no current to pass at the ordinary pressures, but at undesirable pressures above normal it should provide sufficient freedom for the flow of current to limit the pressure to safe values, and it should cease to take current and resume its inactive condition the instant the excessive pressure is relieved.

FIG. 1. TYPE MP LIGHTNING ARRESTER
FIG. 2. TYPE MP LIGHTNING ARRESTER FOR POLE MOUNTING

The simplest and therefore the least expensive form of lightning arresters that fulfill these functions is of the spark gap type.

The illustrations show 2 types of spark gap arresters for low-voltage use, manufactured by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa. The type MP is used on cars, on lines, and in stations, for railway service, and the type C is an inexpensive device for the protection of overhead lines.

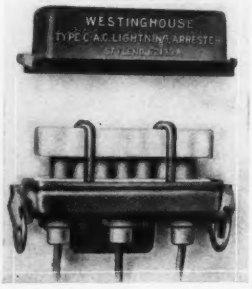


FIG. 3. TYPE MP LIGHTNING ARRESTER FOR CONDUIT WIRING
FIG. 4. TYPE C LIGHTNING ARRESTER

The type MP or multipath arrester, for use on 440 volts alternating current or 600 volts direct-current, has for its working part a block of special composition, over the surface of which the discharge spreads itself along a number of minute discharge paths. The voltage across each gap is very small, but owing to the large number of gaps the line voltage can not maintain an arc across them. The arrester has an indefinitely long life and affords a freedom of discharge very great compared with ordinary air spark gap types.

For installation under various conditions, 3 different styles of enclosing cases are furnished for the type MP arrester. In all 3 the cases are of galvanized iron and substantially constructed. The covers close against felt gaskets and are held by rugged spring-toggle latches. The car mounting style (Fig. 1) is so constructed that when the cover is removed the working part comes out with it; it is therefore convenient for mounting under car sills and in other inaccessible places. The pole-mounting style (Fig. 2) has the mounting lug located at the bottom, so that the cover can be removed for inspection without dropping out the working part. The conduit-wiring style (Fig. 3) is mounted in a larger box having a conduit hole tapped with standard ⅜-in. pipe thread; the ground lead is connected directly to the box, and the conduit system should be grounded.

About 5 type MP arresters per mile are recommended by the manufacturers for line protection, and 1 on each car.

The type C arrester, for 500 to 2500 volts alternating current, consists of 7 cylinders of non-arcing metal mounted between overhanging porcelain supports and enclosed in a weather proof iron box. Leads are brought out from the first, last, and middle cylinders. For lines up to 1250 volts, one arrester can be used as a protection for both sides of a 2-wire circuit, the middle lead being grounded. On higher voltage one outside lead is grounded and the arrester is single-pole. The static charge spreads over the surface of the cylinders and jumps across the gaps between them. This lightning arrester, because of the large size of the cylinders, has an instantaneous current capacity that materially aids in clearing the line of disturbances, while its equivalent spark gap is extremely low. This device has successfully withstood the test of hard conditions and gives reliable protection under the conditions for which it is intended.

The type C arrester is intended for use on circuits having a capacity not exceeding 200 kilowatts if installed within a radius of 2 miles from the source of power. An additional capacity of 100 kw. is permissible for each additional mile. These limits are specified by the manufacturers to allow for the ability of the arrester to suppress successfully a power arc following a discharge.

NEW POWER PLANTS

APPLICATION has been made to the public service commission by the New York and New Jersey Power Co., with headquarters at Middletown, N. Y., for permission to construct a hydro-electric power plant on the Neversink River, about 6 miles southeast of Monticello.

THE MCCLINTIC-MARSHALL CONSTRUCTION CO., of Pittsburgh, has employed Chester & Fleming, hydraulic engineers, to make an investigation of the water system of the borough of Rankin. This is with a view of rebuilding the system in the near future.

THE PENNSYLVANIA POWER CO., a subsidiary of the Mahoning & Shenango Valley Light Co., is making a survey for a dam on the Shenango River near Hazel Dell, Pa. The power company was recently purchased from the Ellwood City owners by the street railway corporation. The steam turbines were taken out and all power is now being generated by water, which has reduced the cost to a minimum. A high power line has been built to New Castle and the power generated in Ellwood City and sent to the main line. This furnishes power for New Castle, Warren, Sharon, Youngstown and intermediate points.

THE MANAGEMENT of the city light and water plant at St. Francisville, La., has under consideration plant improvements to cost about $6000.

WORK ON THE NEW municipal electric light and power plant at Alameda, Cal., is progressing satisfactorily. The lesser buildings have been completed and the work of pouring the concrete in the battery house forms is under way and the new power plant proper will soon be commenced.

THE METROPOLITAN ELECTRIC CO., of Reading, Pa., has decided to rebuild its plant along the Schuylkill River below the city. It will furnish 4000 hp. The Reading Transit Co. is closing a contract at Phoenixville for a 3200-hp. plant on the Schuylkill River at that point. The contract for power at the Norristown dam is practically completed. More than 3200 hp. will be developed.

THE CHATTANOOGA & TENNESSEEE RIVER POWER CO. will begin at once the construction of a $1,000,000 steam power plant, to be operated in connection with the $8,000,000 plant now being erected at Hale's Bar.

Just where the building is to be erected has not been decided, but it will probably be at the lock and dam. There is a possibility, however, that it will be put in Chattanooga or even at some point along the transmission line of the power company between Guild and Chattanooga. The capacity of the plant is to be 20,000 or 25,000 hp.

ON AND AFTER MARCH 1, 1913, Jenkins Bros. will be located at 524 to 530 Atlantic Avenue, opposite foot of Pearl Street, Russia Building, Boston. After nearly 50 years of successful business the last 10 years at 35 High Street, the company is again cramped for room, and in order to take care of its increased business has taken a lease for a long term of years subject to renewal, at the above-named location, with 3 times the amount of floor space, centrally located, including excellent shipping facilities for handling present tonnage and taking care of a greater volume.

ALL RESIDENCE BUILDINGS in Ft. Wayne, Ind., on the north side of Wall between Union and College streets, purchased by the General Electric Co. some time ago, must be vacated by March 10, 1913, according to notices that have been received by the occupants, and the work of removing or razing the buildings will be commenced immediately to make room for a new 4-story factory building to be erected west of the large foundry building west of Broadway. Building operations will be started as early as possible in order to have the new structure ready for occupancy next fall. A large portion of the new building will be given over to the manufacture of transformers and the ice making and refrigerating machines.

The General Electric Co. owns all the ground on both sides of Wall St. between Broadway and College St., with the exception of the Rastetter property on Broadway, which cannot be purchased at the present time. All buildings situated in this district will be removed within the next few years to make room for additional factory improvements.

ALTERATIONS AND IMPROVEMENTS are to be immediately undertaken by the New Bedford Gas & Edison Light Co., and the whole power plant at New Bedford, Mass., is to be rebuilt in the most modern fashion, at an estimated expense of $200,000. Oliver Prescott, president of the company, said that there are at present 2 almost new 1000-kw. generators already installed at the power house. These generators are to be continued in use and will supplement the 4000-kw. turbines which are to be put in. One of these large turbines is to be used as a reserve unit in case anything breaks down, but the other will be in use along with the 2 smaller generators. This will give the power plant an ordinary capacity of 6000 kw., a capacity, which Mr. Prescott said was possible of being over-loaded for short stretches of time. As the peak load of the station at the present time is about 2000 kw., the new equipment will allow room for a considerable growth of business, while the new buildings which are to be erected and the room that is saved by the increased compactness of the modern generators, will allow space for still more machinery when this is needed. The greater part of the old power house building is to be torn down, rebuilt and enlarged, only the newly built section containing the machinery room being left standing.

IMPROVEMENTS AT THE MANCHESTER ST. power station of the Rhode Island Co. at Providence, R. I., that will cost about $750,000 and eventually give the plant about 75,000 hp. are under way and it is said also that the New Haven road, which owns the local traction company, is to erect either a separate power plant or make additions to the Manchester street station, giving the plant 115,000 hp.

The improvements now under way will comprise the erection of 2 additions to the present power house and will mean the installation of 2 15,000-kw. steam turbines, each of which cost $340,000. At present there is one 15,000-kw. turbine in operation there which provides power for the entire Rhode Island Co. system, including the lines that radiate to the Attleboros.

With the 2 additional turbines, when they are set up, and one of them will be installed within a year, the Rhode Island Co. will have a surplus of power. What will be done with this excess the railroad officials are not prepared to state. It is said, however, by some people that some of this power, and in fact a great deal of it, will be transmitted into Connecticut.

The New York, New Haven and Hartford Railroad Company is at present engaged in plans for the electrification of the entire system.

The construction work at Manchester St. is now underway and the piles are being driven. It is thought the buildings will be completed and one of the turbines in operation within a year. The turbines are made by the General Electric Co. and take a long time in construction. Each represents an addition to power capacity of the company that will be almost as much as that now in use. The present power capacity is figured at 55,000 kw., but the steam turbine now in use with a power generating 15,000 kw. is doing practically all of the work of the company and doing it easily.

BOOK REVIEW

FOR THOSE DOING BUSINESS in foreign countries, a book recently issued by the Bureau of Foreign and Domestic Commerce, dealing with the credit problem, will be found of value. Part of this book, written by A. J. Wolfe, treats of the credit, methods and facilities in Germany, England and France, and shows how and by whom long terms of credit are granted in the export markets, and the benefits or disadvantages of the system.

Reports from American consular officers describe fully local credit conditions, so that the reader can get an accurate idea as to what is and is not safe in granting foreign credits. Lists of banks in the United States having foreign departments, and of foreign banks undertaking the collections of drafts are also given.

Copies of this book, Special Agents' Series No. 62, may be obtained for $.30 a copy from the Superintendent of Documents, Government Printing Office, Washington, D. C.

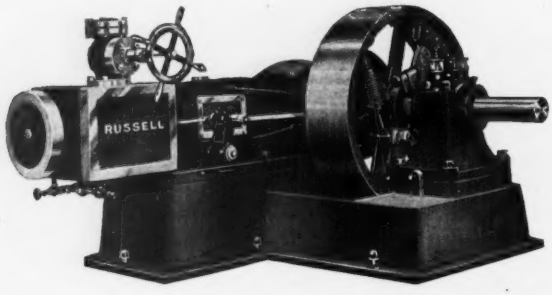
WATER, ITS PURIFICATION AND USE IN THE INDUSTRIES. By Wm. Wallace Christie. D. Van Nostrand Co. Price $2.00. This book, which has just come off the press, is one of the most comprehensive and practical which an engineer could place in his library. It deals, first, with the purification of water, taking up the sources, impurities, uses, reagents, and the methods of purifying for the various industries. Following this chapter are 2 on water softening, dealing with both the cold and hot processes. The results accomplished by softening systems are then dealt with, and a chapter is devoted to the use of pressure filters for industrial purposes. Aeration, sterilization, ozone and ice are taken up in another chapter, followed by one discussing drinking water and the use of open filters, alum, chloride of lime, and tannin. The various methods of measuring and recording the weights of water for industrial purposes are described in another chapter, followed by a discussion of oil filters and boiler water. The last chapter contains a number of tables used in calculation of problems dealing with water. The book is thoroughly illustrated with color plates, half-tones and line drawings which make it attractive as well as easily understood.

ESSENTIALS OF ELECTRICITY by W. H. Timbie, 5 by 7 in., bound in cloth, flexible covers, 271 pages, price $1.25. This is a direct-current textbook for wiremen and electrical workers and is full of meat for the practical man. It is based on notes which the author has been using in short trade courses for students who wish to enter or advance themselves in one or another of the electrical trades.

The book contains 9 chapters which cover not only the elementary principles of electricity but many practical problems encountered in everyday work, which are fully illustrated and explained. At the end of each chapter numerous examples for practice are introduced which relate to the subject matter in the pages before them.

CATALOG NOTES

THE GRISCOM-RUSSELL CO., in its latest bulletin, No. 801, illustrates Russell steam engines for isolated plants and central stations, and all installations having combined lighting and power circuits. The illus-



tration shows the gear side of a Russell automatic single-valve engine. Copies of the bulletin may be obtained by addressing the company at 90 West St., New York.

HOW THE RICE REGENERATOR produces secondary combustion is explained on a card, mailed to those interested, by the manufacturer, Rice-Watts Co., 15 Federal St., Boston. This device injects a vaporized mixture or oxidized fuel oil in the path of the gases with the idea of completing combustion, eliminating smoke and producing draft.

BUFFALO FLEXIBLE COUPLINGS are illustrated in a circular recently issued by Bogart & Co., Buffalo, N. Y.

HOPPES STEAM SPECIALTIES are described in a pamphlet recently issued by the Hoppes Mfg. Co., Springfield, O.

THE OHIO BRASS CO., of Mansfield, Ohio, has issued a February circular on Ohio radiator, globe, angle, check and gate valves.

A FOLDER ENTITLED "A Few Platt Products" illustrates some of the pumps and engines manufactured by Platt Iron Works Co., Dayton, Ohio.

BULLETIN NO. 113 just received from the Goulds Manufacturing Co., Seneca Falls, N. Y., gives a complete list, descriptions and illustrations of the rotary pumps made by this company.

HAMMOND WATER METERS are illustrated by sectional views and one showing the valve mechanism, in Bulletin No. 100 from Alberger Pump and Condenser Co., 140 Cedar St., N. Y.

FROM GREENE, TWEED & CO., 109 Duane St., New York, we have received a 96-page catalog, No. 10, describing and illustrating mill supply and hardware specialties. These include the various types of Rochester automatic lubricators.

HISTORICAL SOUVENIR No. 4, dealing with George Washington, has been received from Jefferson Union Co. This circular also emphasizes the construction and location of the brass seat ring in Jefferson unions.

SMOOTH-ON MANUFACTURING CO., Jersey City, N. J., has issued a 6-page circular showing some of the ways in which Smooth-On iron cement, for concrete, is used—for waterproofing engine pits, flywheel pits, tanks, etc. Any engineer sending his name and address to the company may obtain a sample of the cement free of charge, also a 40-page instruction book.

THE VULCAN 4-year calendar provides for an unusual amount of usefulness and is illustrated by a photograph of Williams' wrenches taken from the 57th story of the Woolworth building in course of construction in New York City. The calendar may be obtained by addressing J. H. Williams & Co., 10 Richards St., Brooklyn, N. Y.

HUNT NOISELESS BUCKET CONVEYOR is automatic in operation; the buckets are made of open-hearth steel or of cast iron and are pivotly hung on a steel shaft in a heavy steel chain driven by pawls. A full description and many illustrations are given in Catalog No. 12-9, from C. W. Hunt Co., West New Brighton, N. Y.

BRISTOL'S RECORDING INSTRUMENTS for pressure, temperature, electricity, speed, time, etc., are described in condensed catalog No. 160. Illustrations include facsimile charts from recording thermometers with records of feed-water and superheated steam temperatures. These instruments are manufactured by the Bristol Co., Waterbury, Conn.

THE GENERAL ELECTRIC CO. has just issued Bulletin No. A4081 devoted to the subject of reversing motors for planers, slotters, etc. The subject is treated in considerable detail, and the publication contains various curves which show the advantage of direct drive over belt drive, and, therefore, the advantage of reversing motors. The bulletin illustrates also various auxiliary appliances.

Sparks From The Advertising Pages

Professor Hugo Munsterberg, the eminent psychologist at Harvard University, outlines the results of some exceedingly interesting as well as valuable experiments on the attention value of advertisements in his study of Psychology and Industrial Efficiency.

He calls attention to an experiment made by Professor W. D. Scott, who constructed a book of one hundred pages from advertisements which had been cut from various publications. Fifty persons were asked to glance through the book as they would the advertising section of a magazine. They were given ten minutes in which to do this.

Then they were asked to write down what they remembered. The result was that every full-page advertisement was mentioned six and one-half times, every half-page less than three times, every fourth-page a little more than one time and the still smaller ones only about one-seventh time.

This would suggest that the memory value of a quarter page advertisement is considerable less than one-fourth of the memory value of the full-page; that the attention value of the eighth page is much less than half of that of the quarter. So that the man who buys an eighth-page, says Professor Munsterberg, buys not the eighth part, but scarcely the twentieth part of the influence produced by the full-page or unit of space.

Professor Munsterberg has experimented in his own laboratory with equally as interesting results, but along somewhat different yet supplementary lines.

He took sixty sheets of Bristol board in folio size and covered them with advertisements cut from magazines, ranging in size from full pages to twelfth-pages.

Thirty persons were allowed to look at each sheet for twenty seconds. The full-page advertisement occurred but once, the half-pages twice, the quarter-pages four times, the eighth-pages eight times and the twelfth-pages twelve times. But the same advertisement never occurred twice on the same page, for unless covered by a full page, each sheet offered a variety of announcements. Thus no advertisement was spatially favored above another.

The result showed that the twice-repeated half-page was remembered slightly better than the full-page which had been shown but once—that the four-times repeated quarter-page was remembered even better than the twice-repeated half-page.

It would seem to follow, therefore, that while the full-page constitutes the most valuable advertisement, the repetition of four quarter pages in the same medium would stand a better chance of being remembered than the use of just one full-page.

This bears out the well-known fact that by far the larger part of the money lost through unproductive advertising has been due to spasmodic rather than persistent and consistent campaigns.

What are your own impressions with regard to relative space values, Mr. Reader? We would be glad to publish some of your opinions in our discussions here on this page. Let us hear from you.

PRACTICAL ENGINEER CLASSIFIED ADVERTISEMENTS

Advertisements in this section are inserted under regular headings at the rates of 30 cents per line. About nine words make a line. No display type allowed, but the first three words may be set in capital letters. Minimum space sold, two lines.

Under classification, "Positions Wanted," advertisements not exceeding four lines will be inserted for subscribers once free of charge.

To insure proper classification, copy must reach this office 10 days preceding publication.

Positions Wanted

POSITION WANTED—By engineer, age 32, married, reliable, do not drink. 14 years' experience with all classes of Power House equipment. Own tools and indicator. Prefer Western States. Can get results. Address Box 283 Practical Engineer, Chicago, Ill. 3-15-1

POSITION WANTED—By a young man 25 years old as Oiler. I. C. S. Student. No experience. Wages no object. Good habits. Steady and reliable. Address Frank Knapp, 509 Mitchel Ave., St. Joseph, Mo. 3-15-1

DO YOU NEED MEN?—All clerical, commercial and technical departments. Charges low,—one reason we get efficient men. Efficient Service Co., 1340 Monadnock Bldg., Chicago.

Wanted

WANTED—A good opportunity in this territory for a man of character and ability as a salesman. Must have thorough practical knowledge of steam plant conditions. One who is at present handling steam specialties preferred. State age and full particulars. Address Box 285 Practical Engineer, Chicago. 3-15-4e.o.i.

WANTED—A young man with some knowledge of steam and electricity, small plant, furnishing electricity for lighting small town about 100 miles west of Chicago, one who desires to learn the electrical business. $40.00 per month to start. Hours 1 P. M. to 12:30 midnight, must be strictly sober. Address Box 284 Practical Engineer, Chicago, Ill. 3-15-1

WANTED—ALL STEAM USERS to have clean boilers without using compounds or chemicals in any form. Write "Otis," No. 317 Norfolk Ave., Buffalo, N. Y. tf.

WANTED—SALESMEN calling on firms with stationary engineers, to write us for desirable open territory, where they can soon build up permanent business with our guaranteed product insuring repeat orders. Address 322 Real Estate Trust Bldg., Phila., Pa. 2-15-24

IF YOU ARE a night engineer, spend a few hours each day taking subscriptions for Practical Engineer. You will be paid well. Write Subscription Dept. They will start you in at once. tf.

WANTED—SALESMEN SELLING Steam Plant Supplies, to carry as side line, ideal pump valves and plunger packing. Best Valve proposition on the market. Liberal commission and protection in territory allotted. Several entire and part States open. Sample weighs four ounces, easily carried in pocket. If you are looking for a good side line, address, giving full particulars as to territory covered. Lake Erie Boiler Compound Company, Buffalo, N. Y.

WANTED EVERY ENGINEER to have our pamphlet for setting valves on Corliss Engines, simple and compound, with one or two eccentrics. Sent free. Lindstrom's Machine Works, 200 South Third St., Allentown, Pa. tf.

Help Wanted

WANTED—An additional subscription solicitor wanted to cover towns in state of Washington. Excellent chance to earn extra money. Write to Subscription Department. tf.

WE NEED MEN—All departments—clerical, commercial and technical. Charges low. Work covers the U. S. Efficient Service Co., 1340 Monadnock Bldg., Chicago.

For Sale

FOR SALE—10 ton ice plant for sale or trade, new, good water supply, good proposition for electric light and water works in addition. Good town. Birch Tree State Bank, Birch Tree, Mo. 3-15-1

FOR SALE—One 75 H. P. horizontal Struthers Wells Gas Engine. As good as new, run only very short time. Address Shearman Brothers Co., Jamestown, N. Y. 3-15-1

FOR SALE—FOUR DIRECT CONNECTED engine and generator sets 25 to 75 kilowatt capacity. Two 17x15-inch straight line engines, built for direct connection or belted service. One 14x12-inch, late type, automatic and one 16x36-inch Corliss engine, water tube and horizontal boilers of all sizes. Twenty-two round, open steel tanks 10 feet 6 inches by 7 feet high. H. P. Brearley, 90 West St., New York, N. Y. 2-15-4

FOR SALE—Three 150 H.P. HRT. Boilers (Massachusetts specifications), quadruple riveted, double butt strapp, 140 lb. insurance certificate, $550 each. Duzets & Son, Hudson Terminal, New York.

FOR SALE—A 32 H. P. HORNSBY-AKROYD Oil Engine with starting device, in very good condition; also a 15-ton Challoner refrigerating machine, oil separator, double pipe ammonia condenser and high and low pressure gauges. These are also in good condition. For particulars inquire of the Rahr Br'g Co., Oshkosh, Wis. 1-1-6

Patents and Patent Attorneys

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 608 F St., Washington, D. C. Established, 1883. I make a free examination and report if a patent can be had and the exact cost. Send for full information. tf.e.o.i.

PATENTS AND TRADEMARKS secured. Write for terms. Harry Patton, 330 McGill Bldg., Washington, D. C. tf.

PATENTABLE IDEAS WANTED—Send for 3 free books. R. B. Owens, 28 Owens Bldg., Washington, D. C. tf.

THE PATENTOME is interesting and instructive. A liberal education in patents and how to get them. Free on request. Established 1865. Anderson and Son, Patent Solicitors, 710 G Street, Washington, D. C. 3-1-2

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. 186 McGill Building, Washington, D. C. tf.

Educational and Instruction

HEATING CALCULATIONS SOLVED instantly with the steam and hot water radiation calculator. Sent on approval. Return if not satisfactory. Remit 50c if kept. Watertown Specialty Co., Watertown, N. Y. 3-15-2

ENGINEERS' POCKET MANUAL, 175 pages, edited by University of Tennessee will be mailed every subscriber sending in one new subscription to Practical Engineer. Gilt edges, bound in leather. tf.

MACHINERY BOOKS 25c each. 92 titles. Circular free, "Steam Boilers." Steam Engines. Bevel Gearing, etc. Scientific Book Shop, Syracuse, N. Y. 3-15-1

Miscellaneous

ENGINEERS—DO YOU WANT to utilize your exhaust steam for heating or drying purposes, without back pressure on your engine? If so, address Monash-Younker Co., 1413 W. Jackson Blvd., Chicago, Ill. tf.

MAKE MONEY on the side. Here's your chance to work out some money for yourself. Get subscriptions for Practical Engineer. It pays well. Just drop a line to the Subscription Dept. They will tell you how. tf.

REFRIGERATION—Any engineer desiring a working knowledge of Ice and Refrigerating machinery should study "Audel's Answers on Refrigeration"—just published in two parts, written in plain language—price $4, postpaid. Money back if not pleased. Catalog free. Theo. Audel & Co., publishers, 72 5th Ave., New York. 2-1-6